ISSN 2663-8169 Vol. 5, Issue 24: 126-130, DOI: 10.25236/IJNDE.2023.052420

Practice and Exploration of Teaching Reform of Automatic Control Principle Course in the Context of New Engineering Subjects

Zhuye Xu, Zhuoqun Li

Lanzhou Jiaotong University, Lanzhou, Gansu, 730070, China

Abstract: *In order to respond to the demand of "new engineering" to cultivate talents with strong practical ability, high innovation ability and excellent professional quality, colleges and universities need to reform and innovate the teaching mode of engineering majors. Principle of automatic control course has significant advantages in cultivating students' practical and innovative ability, but there are still some teaching problems. In order to better meet the requirements of students in new engineering disciplines, it is necessary to improve the teaching defects of automatic control principle course to cultivate high-quality talents. By analysing the connotation and teaching problems of the course, and combining with the background of "New Engineering", the experimental teaching mode is explored and reformed. It is recommended to revise the experimental syllabus and increase the experimental hours to ensure that students have sufficient time for practical operation and experimental design. At the same time, a simulation experiment system is established to provide a wider range of experimental scenarios and practical opportunities. Emphasis is placed on designing a variety of experimental types to help students continuously improve their practical ability and innovative awareness. Innovative experimental teaching methods are advocated to introduce project-based experiments and collaborative experiments, etc., to stimulate students' creativity and teamwork spirit.*

Keywords: *new engineering; principle of automatic control; teaching reform*

1. Introduction

In the context of new engineering disciplines, it is required to cultivate comprehensive talents with strong competitiveness, high innovation ability and practical ability. In order to meet this requirement, engineering majors need to improve the teaching of automatic control principle courses, especially in practical teaching.

From the perspective of training students in traditional engineering colleges and universities, the teaching of automatic control principle courses usually stays only at the theoretical level and lacks the support of experimental teaching, which leads to students' deficiencies in practical and innovative abilities. Therefore, under the guidance of the new engineering thinking, we need to innovate and improve the experimental teaching mode of automatic control principle course according to the actual teaching needs, in order to cultivate emerging engineering talents with strong practical ability, innovation ability and coordination ability.

2. Principles of Automatic Control Course Description

With the progress of science and technology, automatic control technology has been widely used in various engineering and non-engineering fields. As a methodological discipline, automatic control is devoted to the study of the construction, analysis and design of control systems. Principles of automatic control is the core course for students to learn this discipline. Principles of automatic control plays an important role in the training of talents in colleges and universities. It is a basic course for automation majors and related disciplines, and one of the core of electrical, electronic information, computer and instrumentation majors. The course not only covers a wealth of theoretical knowledge, but also emphasises practical application, both engineering and methodological.

The study of the automatic control principle course mainly includes the basic composition and structure of automatic control systems, performance evaluation indexes, types and design methods [1]. In the context of "new engineering", the course emphasises practical teaching and cultivates students'

ISSN 2663-8169 Vol. 5, Issue 24: 126-130, DOI: 10.25236/IJNDE.2023.052420

practical, innovative and coordinating abilities. Therefore, in view of the current deficiencies in the experimental teaching of automatic control principle course, it is necessary to make corresponding improvements to better meet the needs of cultivating complex talents.

In terms of experimental teaching, the practical hands-on ability of students in the automatic control principle course should be strengthened, and students should be allowed to participate in the construction, debugging and performance evaluation of the control system through diversified experimental projects, so as to cultivate their problem solving and innovative thinking ability. In addition, commonly used control system tools and software, such as MATLAB, Simulink, etc., can be introduced to familiarise students with practical application tools and improve their engineering practice. In order to enhance the connection with industry, real-life cases need to be integrated into the Principles of Automatic Control course so that students can better understand the application of automatic control technology in real engineering projects. Such an improvement will fully prepare them to face the challenges of their future careers. Through these measures, the Principles of Automatic Control programme will better meet the needs of modern engineering education.

3. Teaching Issues in Principles of Automatic Control Courses

The course Principles of Automatic Control is well known for its theoretical and abstract content as well as its relevance. However, the traditional teaching mode relies too much on textbooks and blackboards, overly favouring mathematical derivation and neglecting the explanation of physical concepts. At the same time, the over-emphasis on theoretical content has neglected the cultivation of engineering applications and students' abilities.

3.1 Teaching and learning in a single way

Multimedia teaching, as the main teaching tool commonly used by university teachers at present, employs the characteristics of convenience, efficiency and intuition, injecting a new impetus to the improvement of teaching and playing an obvious auxiliary effect. It can demonstrate lengthy concepts, abstract principles and complex calculations in a concise and easy-to-accept way. However, for courses such as Principles of Automatic Control, which is highly theoretical, there are some troubles in relying too much on a single form of multimedia courseware teaching. This is not only easy to make students feel tired, but also not conducive to the growth of young teachers.

For example, when introducing the mathematical model of an automatic control system, it is necessary to construct a differential equation of an actual physical system according to the physical laws and obtain the transfer function of the system by transforming it into a mathematical system using Laplace transform to obtain the mathematical model. Presenting this part of the content by courseware alone cannot well attract students' attention and is not conducive to their understanding and mastery of knowledge.

Therefore, multimedia teaching needs to be skilfully applied in the Principles of Automatic Control course to avoid over-reliance. Rich examples can be used to explain and introduce case studies. In addition, interactive teaching [2] can also be used to allow students to actively participate in discussions and practical operations, so as to improve the motivation and effectiveness of learning. Only in this way can we better develop students' ability and understanding, and at the same time enhance the teaching level of young teachers.

3.2 Course content is overloaded

The Principles of Automatic Control (PAC) course provides an in-depth treatment of the creation, analysis and design of control systems in the form of a methodology [3] and includes both important aspects of classical and modern control theory. The course encompasses a wide range of subject areas, including mathematics such as the solution of differential equations, Laplace transforms, and matrix analysis. It is also integrated with areas of physics such as mechanics and thermodynamics, and covers specialist course content such as circuit theory, electrical machines and drag, and analogue electronics. Students need to develop their mathematical modelling skills and be able to integrate what they have learnt to solve practical problems.

However, due to the huge amount of information and the vast scope of the subject, it is often difficult for students to absorb what they have learnt in a timely manner, which has a certain impact on

ISSN 2663-8169 Vol. 5, Issue 24: 126-130, DOI: 10.25236/IJNDE.2023.052420

the teaching effect. Teachers therefore need to adopt effective teaching methods, such as the skilful use of pedagogical tools, the introduction of case studies and interactive teaching, in order to help students better understand and master the subject content, stimulate their motivation to learn and improve their academic performance. In addition, students need to be actively involved in learning and to emphasise the integration and practical application of knowledge in order to realise the full potential of the course and to develop their general and practical problem-solving abilities.

3.3 Lack of course practice

Principles of Automatic Control is an engineering practice course that has an important impact on students' comprehensive ability and practical ability. However, at present, colleges and universities still focus on theoretical education and neglect experimental teaching, which leads to certain limitations in students' ability to combine theory with practical problems. Although there are some experimental courses, due to the limitations of experimental conditions and equipment, these experiments usually involve only the assembly of simple analogue circuits or simulation experiments based on MATLAB, which can not really enhance the students' hands-on ability and the ability to solve real-world problems, and at the same time lead to the lack of students' understanding of and attention to the practical aspects.

In order to solve this problem, it is necessary to strengthen the practicality of course design and increase more opportunities for practical operation. This can be achieved by improving laboratory facilities and equipment, adding more experiments with real-life scenarios, and introducing methods such as engineering projects and case studies. Improvements in this way can stimulate students' interest, encourage them to actively participate in experimental activities and apply the theories they have learnt to solve practical problems. In addition, the link between the curriculum and the industry should be strengthened, and practical projects should be launched in co-operation with enterprises, so that students can immerse themselves in real engineering environments, cultivate their hands-on and practical abilities, and at the same time improve their ability to solve complex problems.

By strengthening practical teaching, students can more comprehensively comprehend and master the knowledge and skills contained in Principles of Automatic Control, and further enhance their practical engineering ability and competitiveness in employment. At the same time, this move also helps to cultivate students' innovative thinking and problem-solving ability, laying a solid foundation for their future development in the engineering field. Therefore, it is of great significance to improve the practical teaching aspects of the Principles of Automatic Control course, which also deserves great attention and constant innovation from the university education sector.

4. Pathways to curriculum reform

4.1 Innovations in teaching methods

As a highly theoretical subject, the teaching of automatic control principles should be fully aware of the students' learning situation, so we advocate the use of diversified teaching methods aiming to better meet the students' learning characteristics. In the teaching process, case studies should be used to interpret open-loop control systems and feedback control systems. Firstly, the concepts, advantages and disadvantages of these two systems should be clarified, followed by detailed discussion with examples, so that students can understand these concepts exactly and use them flexibly in practical applications. In addition, for the time-domain analysis of second-order systems, we apply the discussion method and categorise them into four cases according to the differences in damping ratios: zero damping, under-damping, critical damping and over-damping. Such an approach led the students to explore in depth the eigenroots and step responses of the second-order system in each case. This not only stimulated the students' academic thinking, but also fostered their self-directed learning skills and increased their motivation. The skilful application of this teaching method plays a positive role in students' better understanding and mastery of automatic control principles and stimulates their enthusiasm in academic exploration.

In the reform of teaching methods, the traditional teaching mode of the board book should be broken through, and modern teaching tools should be actively integrated. Multimedia resources should not be limited to simple PPT text, giving full play to its advantages. For example, when introducing the concept of root trajectory, multimedia animation can be used to demonstrate the changes of different parameter K values on the closed-loop characteristic root in the S-plane, in order to help students intuitively understand the evolutionary process of the root trajectory [4], and strengthen their

ISSN 2663-8169 Vol. 5, Issue 24: 126-130, DOI: 10.25236/IJNDE.2023.052420

understanding of the concept. In addition, relevant online resources can be actively recommended to students to broaden their knowledge horizon and deepen their learning. This innovation in teaching method not only makes students more actively involved in learning, but also develops their problem solving and analytical skills to better face the challenges of the theoretical discipline of automatic control principles.

4.2 Optimisation of teaching content

Principles of Automatic Control has a limited class time, but the content is so broad that we need to optimise the content in order to ensure that students are not only aware of the relevant knowledge, but are also able to apply it proficiently. In doing so, we were able to omit the concepts of the Raschmann transform, Z-transform, and complex numbers, which are explored in detail in Complex Functions and Signal Analysis, in order to avoid repetitive narratives. This allowed time and effort to be focused on highlighting new concepts and key knowledge points in the Principles of Automatic Control course.

In order to highlight the importance of theoretical knowledge in practical applications, we can select case studies related to the fields of circuits and mechanics that students are familiar with as proofs. In this way, we can make more efficient use of the limited study time by directly introducing new concepts and application methods in the course without having to repeat the basic principles again. With this optimised teaching method, we can effectively improve students' understanding and application of what they have learnt, and develop their problem-solving and practical skills. Even with a limited amount of time, we can ensure that our students gain a wealth of practical knowledge in Principles of Automatic Control by carefully designing and optimising the content of the course.

4.3 Practical session enhancement

Principles of Automatic Control (PAC) is a challenging course that is closely related to practical engineering. This means that during the teaching process, we need to ensure that students focus not only on theoretical knowledge but also on practical applications. Practical sessions are not only a test of theoretical knowledge, but also deepen understanding. When teaching theoretical courses, we can skilfully incorporate practical elements. For example, when introducing PID control, the basic theoretical knowledge is first taught, then combined with circuit knowledge, the circuit is designed, including components such as resistors, capacitors and inductors, and step signals are applied to observe the corresponding response curves. Then, by adjusting the parameters, the change of the curve is again observed so that the students can understand the theory more intuitively. It is also necessary to pay enough attention to the experimental class to provide students with a practical platform to deepen their understanding of the theoretical knowledge through practical operation. Students are encouraged to use the practical platform to analyse and investigate real systems to enhance their understanding of the relationship between theoretical knowledge. This can stimulate students' learning interest and operational ability, and lay a solid foundation for subsequent related courses.

In addition, students are actively encouraged to participate in various professional competitions related to automatic control, such as intelligent vehicle competitions and robotics competitions. By participating in these competitions, students will not only be able to flexibly apply the theoretical knowledge they have learnt, but also be able to understand how to apply the theoretical knowledge to practical situations and realise the organic combination of theory and practice. This will help them to better cope with future engineering challenges [5].

4.4 Reform of experimental teaching mode

Under the requirements of "new engineering", the experimental teaching mode of automatic control principle course must be profoundly improved to ensure that it has the characteristic of openness [6]. Although engineering colleges and universities are limited by many factors and cannot completely open all experiments, we can take a series of innovative initiatives to adapt to the new teaching concept. Firstly, providing students with greater flexibility and autonomy through online course selection and lab time booking enables them to better organise their studies. Second, place students in the leading role in laboratory teaching, so that they can become creators and practitioners of knowledge, while teachers play a guiding and supporting role. In addition, teachers need to choose their teaching methods skilfully according to the different abilities and foundations of their students, with both exemplary teaching to help those who need extra guidance, and encouraging capable students to carry out independent research and experimental design to meet their individual needs. Through these

ISSN 2663-8169 Vol. 5, Issue 24: 126-130, DOI: 10.25236/IJNDE.2023.052420

improvements, we can better adapt to the requirements of "new engineering" education and cultivate students' innovative spirit, practical ability and problem-solving ability.

5. Conclusions

The reform of the Principles of Automatic Control course is part of an ongoing effort to keep pace with the rapid advances in modern engineering and the demands of "new engineering" education. The importance of this course cannot be underestimated as it provides students with the critical foundation needed to succeed in the field of control and automation. Through this reform, we are pursuing the goal of integrating theory and practice to produce engineering professionals with innovative, practical and interdisciplinary thinking.

By introducing a modernised course content covering the latest technological trends, students are enabled to cope with increasingly complex engineering problems. Practical teaching becomes the core of the programme, where students will experience first-hand the application of automatic control through experiments and project work, and grow in solving real-world problems. Interdisciplinary collaboration has also become an important part of our approach, as engineering is no longer confined to a single field, but requires the ability to cross multiple subject areas to solve complex challenges. The faculty team is also constantly striving to upgrade itself to better guide the students and stimulate their potential. An assessment mechanism has been put in place to enable us to better understand the progress of our students and make timely adjustments to ensure that they get the most out of their studies.

Finally, it is believed that this reform will bring new directions and opportunities to engineering education. Students will not only master the theoretical knowledge of automation, but will also be equipped with an innovative mindset and practical problem-solving skills that will enable them to excel in the engineering field. We look forward to seeing them make outstanding contributions to society and technological progress in their future endeavours. This is the ultimate goal of the reform of the Principles of Automatic Control course and the driving force behind our unremitting efforts.

Acknowledgements

The article was supported by the 2023 Academic Affairs Office of Lanzhou Jiaotong University's school-level educational reform project (Exploration of Teaching Reform of the Course "Principles of Automatic Control" Based on Online and Offline Interactive Learning Space in the Context of New Engineering) (JGY202339); Lanzhou Jiaotong University 2023 Experimental Teaching Reform Project (Hybrid Experimental Teaching Reform and Exploration of "Automatic Control Principles" Based on Virtual Simulation Experimental Platform) (20230014); Funding for the 2023 Innovation and Entrepreneurship Education Reform Project of Lanzhou Jiaotong University (Exploration and Practice of Teaching Reform in the Course of Automatic Control Principles Based on OBE Concept under the Background of Engineering Education Professional Certification; Integrated Stepped Evaluation Model for Mass Entrepreneurship Education).

References

[1] Hongfeng Tao,Yanjun Liu,Weili Xiong et al. Discussion on the reform mode of automatic control principle course construction under the background of new engineering education[J]. Journal of Higher Education,2020(03):124-126.
[2] Yanjun Liu,Hongfeng Tao,LIU Chenglin et al. Construction and practice of "golden class" of automatic control principle course for new engineering[J]. Journal of Higher Education, 2023, 9(01):94-96+101.
[3] Xuegong Qiao, Pengwei Li,Liqi Fu et al. "Research on hybrid teaching mode of automatic control principle[J]. Journal of Electrical and Electronic Teaching,2021,43(06):61-63+83.
[4] Jianping Shi,Peng Liu. Teaching reform of automatic control principle course under the background of new engineering[J]. Education and Teaching Forum,2019(08):138-139.
[5] Bin Li,Jianming Huang,Zhaoli Xie et al. "Principle of automatic control" course reform thinking[J]. Journal of electrical and electronic teaching,2016,38(03):41-44.
[6] Hong Man, Jianmin Zhang, Yuegang He. Teaching Reform of "Principle of Automatic Control" under the Concept of OBE in New Engineering[J]. Education and Teaching Forum,2020(33):192-193.
[7] Ping Li, Qiming Pan. Teaching Reform of Automatic Control Principle Course under the Background of New Engineering[J]. China Modern Education Equipment,2023(05):91-93+96.