Higher Education and Practice Vol. 2 No. 2, 2025

Research on the Teaching Reform of Computer Network Course Based on CDIO

Xueri Li*, Lei Yang, Huitong Liao
Guangdong University of Science and Technology, Dongguan, Guangdong, China
**Corresponding Author*

Abstract: As one of the core courses of network engineering, the Computer Network course undertakes the important task of training students to master the basic concepts, principles and technologies of computer network and the ability to solve practical problems. However, the current teaching mode still has many deficiencies in content updating, methodological innovation and practical teaching, which is difficult to meet the demand for high-quality innovative talents in the rapidly developing information technology industry. For this reason, this paper introduces the educational concept of CDIO and puts forward a set of systematic teaching reform strategies to improve the teaching effect of the programme and the comprehensive ability of students. It has been proved that the teaching reform based on the concept of CDIO has significantly improved students' theoretical knowledge mastery and practical ability. Students show higher learning interest and initiative in the course learning, and are able to better apply theoretical knowledge to practical problem solving. Through this reform, students can not only master the basic knowledge of computer network, but also improve their comprehensive ability in practice, and become high-quality and innovative computer network technology engineering talents adapted to the needs of the industry.

Keywords: CDIO; Computer Networks; Project-Based Learning; Problem-Based Learning

1. Introduction

With the advent of the 5G era, China's big data, artificial intelligence, Internet of Things, network security, smart cities and other emerging industries in the field of serious talent shortage phenomenon, this effect directly triggered a new talent demand [1]. Driven by the new talent demand, applied undergraduate colleges and universities have repositioned their talent cultivation goals based on the concept of CDIO engineering education, starting from the basic skills of talent cultivation, and cultivating students' ability to find problems, analyse problems and solve problems [2]. CDIO is the acronym of "Conceptualise, Design, Implement, Operate", which integrates engineering education with engineering practice and implements the concept of "Conceptualising, Designing, Implementing, Operating". CDIO is an acronym for "Conceive, Design, Implement, Operate", which combines engineering education with engineering practice and implements the CDIO management process so that students can improve their basic knowledge of engineering, personal technical ability, system engineering ability, and teamwork spirit during the whole life cycle of product conceptualisation, research and development, application, and maintenance [3]. In traditional engineering education, students often have a large disconnect between theoretical learning and practical operation [4]. And the introduction of CDIO concept is to break this situation. It emphasises project-oriented, so that students can learn and master knowledge in practical operation. For example, in the product conception stage, students need to put forward innovative ideas and solutions through market research, technical analysis and other means; in the design stage, students need to use the professional knowledge they have learnt to transform the conception into detailed design drawings and technical documents; in the implementation stage, students need to do it themselves and transform the design into actual products or systems; and in the operation stage, students need to test, maintain

and optimize the products or system; and in the operation phase, students need to test, maintain and optimise the product or system to ensure its stable operation. Through such a complete process, students not only have a solid grasp of professional knowledge, but also develop the ability to solve complex problems in practice.

The goal of the CDIO education model is to develop a set of reasonable, complete, general and generalisable teaching objectives for engineering education. It emphasises the combination of individual competence, social competence and systematic manufacturing techniques and fundamentals, so that students can acquire professional knowledge as well as good communication skills, teamwork ability and social responsibility [5]. This comprehensive education concept is not only applicable to a specific engineering field, but can be widely applied to all engineering fields. Whether in traditional mechanical engineering, electronic engineering, or in emerging fields such as big data and artificial intelligence, the CDIO concept can provide students with a systematic learning framework to help them better adapt to future career development needs.

In today's fast-developing technological era, the reform of engineering education is imperative [6]. The introduction of the CDIO engineering education concept provides a new perspective and method. Through the guidance of this concept, schools can better cultivate high-quality.

2. Analysis of the Current Status of the Teaching of the Computer Networks Course

The course first introduces the basic definition, composition and classification of computer networks to give students an overall understanding of networks. Next, the course delves into the working principles of computer networks, including core content such as data communication, network protocols, routing and switching, and network security. These principles are key to understanding the operation of computer networks. The course will also provide a detailed introduction to various network technologies, as well as their characteristics and application scenarios. In addition, the course will explore the application of computer networks in real life, such as e-commerce, cloud computing, Internet of Things, etc., to help students understand the impact and contribution of computer networks to society. Through the theoretical and experimental teaching of this course, students are expected to have the following abilities: Through studying the computer network course, we expect students to have a comprehensive grasp of the basic concepts, practical operation and application capabilities, including network equipment configuration and management, network security protection, network fault diagnosis and repair, and to continuously improve their innovation ability, problem solving ability and communication and collaboration ability in practice, which will prepare them for their future career development. In addition, they will improve their innovative ability, problem solving ability and communication ability in practice, laying a solid foundation for their future career development.

2.1 Inadequate Analysis of the Match Between Teaching Content and Industry Needs

The rate of knowledge updating in the field of computer networks is extremely fast, and new technologies and applications are emerging [7]. Although many schools and educational institutions have realised that the teaching content of computer network courses needs to match the needs of the industry and have made many efforts to this end, the specific matching analysis is often still not deep enough. For example, in the arrangement of teaching content, the ratio of theoretical knowledge to practical operational skills training may not be precisely adjusted according to the actual needs of the industry. This disproportion may lead to excessive accumulation of theoretical knowledge in students, while in the practical operation ability is seriously inadequate, difficult to meet the practical requirements of enterprises on computer network technology talents.

In addition, the lack of in-depth analyses of developments in the industry is also an important problem with the current teaching content. The teaching content of many courses fails to reflect the development of new technologies and applications in a timely manner, resulting in outdated teaching content. For example, the content of traditional

computer network courses may still remain at the level of traditional network protocols, routing and switching, and other basic theories, with less involvement in these emerging technologies. This makes students need to spend a lot of time to supplement and update their knowledge in order to adapt to the actual work demand when they enter enterprises after graduation.

2.2 Deficiencies in Teaching Methods

Traditional lecture-based teaching is still the main teaching method in many computer network courses [8]. In this teaching mode, teachers mainly impart knowledge through classroom lectures and board books, and students are in the position of passive acceptance. Although this teaching method can systematically impart theoretical knowledge, it has obvious deficiencies in cultivating students' active learning ability, innovation ability and practical ability. For example, students may be able to understand theoretical knowledge in the classroom, but have no way of applying it in practice.

In recent years, new teaching methods and tools such as project-based learning and blended learning have gradually gained attention in the education sector. However, many schools and teachers are still deficient in the application of these new teaching methods. For example, project-based learning emphasises the use of actual projects as a carrier, so that students can learn knowledge and skills in the process of completing projects. However, in actual teaching, many teachers are inexperienced in how to design and implement project-based learning, resulting in irrational project design that fails to effectively enhance students' learning. In addition, the lack of quantitative analysis and assessment of teaching effectiveness is also a common problem when using IT to assist teaching. Although many teachers use multimedia teaching tools, online learning platforms and other technological means, they fail to make a scientific assessment of the actual role of these technological means in improving the quality and efficiency of teaching, making it difficult to accurately judge their teaching effectiveness.

2.3 Inadequate Analysis of the Effects of Practical Teaching Activities

Practical teaching plays a vital role in computer network courses. Through practical teaching, students can apply theoretical knowledge to practical operation. However, the current practical teaching activities often have the problem of insufficient effect analysis [8]. For example, in the design of experimental projects and practical training tasks, many courses fail to fully consider the reasonableness and effectiveness of the tasks. Some experimental projects may be too simple to really enhance students' practical ability; while others may be too complex and beyond the actual level of students, resulting in students encountering difficulties in practice and being unable to complete the tasks.

In addition, the insufficient combination of practical and theoretical teaching is also an important problem in current teaching. In the teaching process of many courses, theoretical teaching and practical teaching are carried out separately, and it is difficult for students to link theoretical knowledge with practical operation. This disconnect makes students unable to flexibly apply what they have learnt to solve practical problems. For example, when learning network protocols, students may be able to understand the theoretical content of the protocols in the classroom, but in the actual configuration of network equipment, they are unable to correctly apply these protocols. This disconnect between theory and practice seriously affects the cultivation of students' comprehensive ability.

3. CDIO-Based Teaching Reform Strategies for Computer Networks Course

Focusing on the development of emerging fields, new knowledge such as network security, data transmission, network system design, etc. is incorporated into the course system. Introduce the latest cutting-edge knowledge, such as software-defined networking, 5G, etc. [9], and design a discussion section reflecting the latest development of network technology around the teaching content of each chapter. Emphasis on practice and application, adopting the teaching method of "from the surface to the inside, from the shallow to the deep, from the easy to the difficult", guiding students to start from the understanding of the basic concepts and technologies, gradually

mastering the working principles and details, and ultimately learning to apply and solve real-world problems. Experiments are designed according to the textbook, such as protocol layering, Ethernet, IPv4, ARP, UDP and TCP, etc. At the same time, ARP spoofing and analysis experiments are added in combination with DNS and DHCP protocols to show the relationship between the experiments and practical applications. Provide extracurricular extension experiments, such as socket programming, classical network simulation tools NS2 and NS3, software-defined network simulation tool Mininet, etc., covering network programming techniques commonly used in practical work and mainstream simulation tools in the field of network research [10].

3.1 Adoption of Project-Based and Problem-Oriented Learning

The characteristics of the Computer Networks course can be briefly summarised as follows: many concepts, complex theories, wide-ranging applications, practicality, and rapid technological updating. For this programme, the ultimate goal is to enable students to integrate what they have learnt to design and build computer networks or web applications, which usually requires teamwork. improve students' engineering practice and innovation ability. In the teaching activities, with the actual engineering projects as the carrier, organised and guided by teachers, based on students' independent and inquiry learning, students are guided to carry out research on relevant contents. The research takes various forms, including searching for development trends through the Internet, obtaining information through libraries, conducting on-site investigations on electronic market equipment and materials, visiting network centres, library information centres or experimental centres to observe the construction and application of networks, and so on. Students work in groups to complete the whole process of practical work, discussing, and ultimately evaluating the projects based on what the students have done together.

The concepts and theories of computer networks are numerous and complex, and students tend to find learning boring. In order to cultivate students' interest in the course, improve teaching effectiveness, develop their thinking, analysing and problem-solving abilities, and combine with engineering project orientation, we try to apply problem-driven learning in classroom teaching. By organising the teaching content, the knowledge points are presented in the form of problems. In the teaching process, problems are presented for specific knowledge points, and students are guided to analyse and solve problems. For example, at the transport layer one can start from a problem-driven perspective: "Are two hosts communicating with each other during network usage?" However, this statement is not clear enough. Imagine: what else is required to use the Internet besides a connection between two hosts? Step by step, students are led to understand that it is the processes within the hosts that are really communicating. Therefore, the protocols used to communicate processes must take these factors into account. Through this teaching method, the classroom atmosphere can be enlivened, students' ability to think positively and solve problems can be cultivated, so that they can have an in-depth understanding and mastery of the knowledge they have learnt, and in the process, they will be guided to explore the extended knowledge beyond the classroom, so as to provide space for students to innovate and enhance their ability to think creatively, and at the same time, to master the basic knowledge.

3.2 Reform the Process of Practical Teaching and Construct a Practical and Efficient Practical Teaching System.

Computer network is a highly applied course, and applied education should pay more attention to experimental teaching. Practical teaching not only deepens and supplements theoretical teaching, but also plays an important role in training students to comprehensively apply what they have learnt, solve practical problems, and deepen their understanding and application of theoretical knowledge of the network. CDIO engineering education concept guides the "Doing Middle School" mode, guiding practice with theory and deepening theory with practice. In the practical teaching system of computer network, the research group not only carefully arranges and designs the experimental contents and types, but also strives for practicability and

diversity, increases the proportion of comprehensive experiments and self-selected experiments, and supplements the physical experiments and simulation experiments. Through flexible and diversified comprehensive design and many comprehensive practices, students are trained to think independently, analyse and solve problems, so that they can understand the technological progress and development trend, thus cultivating the ability of innovation.

4. Conclusion

CDIO concept, as an advanced engineering education model, not only emphasises students' solid mastery of theoretical basic knowledge, but also focuses on cultivating their application ability, teamwork ability and engineering system control ability. This concept closely integrates engineering education with engineering practice, enabling students to gradually improve their comprehensive ability in all aspects of the product life cycle, from conception to operation.

In view of the current problems in the teaching of computer network courses, such as the disconnection between the teaching content and the industry demand, the single teaching method, and the poor effect of practical teaching, it is particularly important to introduce the CDIO education concept. The teaching content is closer to the actual needs of the industry. At the same time, the combination of project-oriented and problem-driven teaching methods can effectively stimulate students' interest and initiative in learning, and help them better understand and apply their knowledge.

Reforming the practical teaching system and constructing a practical and efficient practical teaching mode is the key to improving students' practical ability. By increasing the proportion of comprehensive experiments and self-selected experiments, supplementing physical experiments and simulation experiments, students can continuously explore and innovate in practice, and cultivate the ability of independent thinking, analysis and problem solving. This mode of "learning by doing" not only deepens students' understanding of theoretical knowledge, but also improves their engineering practical ability.

Practice has proved that the application of CDIO concepts to the reform of computer network teaching has achieved remarkable teaching results. Students show higher learning interest and initiative in the course learning, and are able to better apply theoretical knowledge to practical problem solving. Through this reform, students are not only able to solidly grasp the basic knowledge of computer network, but also in practice to continuously improve the comprehensive ability to become a high-quality innovative computer network technology to meet the needs of the industry engineering talent. In the future, with the further promotion and application of the CDIO concept, the teaching quality of computer network courses and the comprehensive ability of students will be greatly improved, providing solid talent support for the development of China's information technology industry.

Acknowledgment

This work was supported by Research team on integrated application of digital infrastructure and financial risk control (GKJXXZ2024005) and Guangdong Institute of Technology Higher Education Teaching Reform Project, No. (GKZLGC2024168).

References

[1] Wang L, Gao G, Xu H, et al. Exploration and Practice of PLC Virtual Simulation Experiment Teaching Based on CDIO Mode. Advances in Educational Technology and Psychology, 2020, 4(1).

[2] Crawley E F, Malmqvist J, Sören Östlund, et al. The CDIO Approach. Rethinking Engineering Education, 2014, 19(5): 1 - 5.

[3] Berggren K, Brodeur D, Crawley E F, et al. CDIO: An international initiative for reforming engineering education. World Transactions on Engineering World Transactions on Engineering & Technology Education, 2003, 2(1).

[4] Edstroem K, Kolmos A. PBL and CDIO: complementary models for engineering education development. 39(5): 539-555.

[5] Sook I S. Directionality and model research that should be aimed at fusion and multi-disciplinary education. KOREA SCIENCE & ART FORUM, 2017, 27137-137.

[6] Wu T. Exploration and practice of talent

training mode of mechanical and electrical specialty under the background of engineering education. IPPTA: Quarterly Journal of Indian Pulp and Paper Technical Association, 2018, 30(4): 444-450.

[7] Kachen Z. Computer Network and Database Security Technology Optimization. Journal of Electronic Research and Application, 2024, 8(6): 188-193.

[8] Zhao T, Zhu J, Jian Z, et al. Developing an Effective System for Engineering Management Education: a Teaching Practice and Evaluation Perspective. Education Sciences, 2024, 14(12): 1412-1412.

[9] Ahmed N R K, Labib M M K E, Manjur K. A comparative study of learning outcomes between video-based and traditional lecture-based teaching in physiology. BANGLADESH JOURNAL OF MEDICAL SCIENCE, 2021, 20(4): 833-839.

[10] Fumin Z, Chen Z, Zunxin Z, et al. Practical Network Coding Technologies and Softwarisation in Wireless Networks. IEEE INTERNET OF THINGS JOURNAL, 2021, 8(7): 5211-5218.