A Review of the Impact of Outcome-Based Education networks on blended course teaching

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Abstract*—With the continuous development of online and offline blended course teaching of system networks, some problems should be urgently solved. For example, there is a lack of timely interaction, frequently adjusting online and offline course content and schedules, facing increasingly differentiated students, etc. To address the problems, a detailed analysis of these problems and research on Outcome-based Education (OBE) is carried out in this paper. Some effective strategies are proposed by combining the distinctive features of online and offline blended course teaching of system networks with the OBE teaching philosophy. The online and offline course contents and instruction designs are optimized according to the network engineering job skills requirements. Students can also submit their assignments in the form of audio or video. While submitting textual experimental reports, students can also submit a video of experimental operation and analysis. In the teaching process, teachers deliberately foster an environment that promotes students' involvement in collaborative learning and encourages co-complete assignments in group work. The teaching practice has shown that the proposed improvement strategies are very effective, and students have achieved good results in multiple important competitions, providing new ideas and methods for the course teaching reform of system networks.

Keywords—*outcome-based education; online and offline blended teaching; system network; teaching strategies.*

I. INTRODUCTION

The teaching quality of system networks significantly impacts students' professional quality and practical ability since it is one of the fundamental core courses of computer science.

The system network course contains many concepts, principles, protocols, technology, applications, and so on, and it's a course with solid theory and practicality. Moreover, with the ongoing advancement and utilization of system network technology, the demand for network engineers is increasing, and the course contents are constantly evolving. The new textbook contains more knowledge, including emerging technologies and applications such as IPv6, wireless networks, and network security. Such up-to-date technologies and concepts make this course more comprehensive and practical and enable students to better cope with the difficult problems that network engineers may encounter. However, it is challenging for teachers and related educators. How to effectively teach the system network course and improve the course teaching quality have become hot topics in the relevant fields.

Many teaching philosophies and strategies have been proposed to improve the quality of system networks course teaching. For example, Problem-Based Learning (PBL) [1], online and offline blending learning [2-3], CDIO engineering education [4-5], and outcome-based education (OBE) [6-9]. These teaching reforms have greatly improved the teaching quality.

The content of system network courses continues to grow, but the teaching time has hardly increased. Moreover, due to the addition of many concepts and principles that are difficult to understand, students need to learn to master this knowledge repeatedly. Therefore, blended course teaching becomes quite suitable for this course as online materials can be accessed infinitely on the Internet. And it's also the need for the construction of first-class undergraduate courses. In particular, during the three-year fight against COVID-19, colleges and universities nationwide responded to the call for suspending classes. However, learning continues, and online teaching is carried out on a large scale. While continuously enriching online teaching resources, it also enriches teachers' experience in online teaching. Although the COVID-19 pandemic has ended and offline teaching has resumed to normal, many teachers have not entirely abandoned online teaching. Instead, they continue to conduct research and implement blended teaching practices.

However, there are also many issues involved in implementing blended teaching. For instance, students lack self-motivation in their studies, the classroom learning atmosphere is relatively poor, the students' questions cannot be promptly solved, and classroom interaction is limited. OBE is the latest achievement in the reform of international engineering education and has been recognized by many countries, including the United States. Currently, OBE has also become increasingly popular in China [10]; it is utilized to promote engineering education reform and improve teaching quality. This paper analyses and researches some problems encountered in the computer network blended course teaching. Some teaching quality improvement strategies based on the OBE are also proposed. The teaching practice has demonstrated the effectiveness of the proposed improvement strategies for improving the course teaching quality of system networks.

II. METHODOLOGY

A. Online and Offline Blended Teaching

Online and offline blended teaching refers to integrating online and offline teaching modes to improve teaching effectiveness [11]. Online teaching can be conducted through live streaming and pre-recorded videos. One great advantage is that students can learn and review courses by replaying them online, without being limited by time and space. Correspondingly, offline teaching is different from traditional face-to-face teaching modes and requires the integration of online teaching to redesign the course content, teaching methods, etc. Therefore, this blended teaching mode based on

"Internet + education" cannot be understood as a combination of online and offline teaching. The best teaching effect can be achieved by fully utilising the advantages of online and offline teaching.

Online and offline blended teaching has transformed from traditional face-to-face classroom teaching to "online + offline" teaching and great changes have occurred in the teaching environment. Online teaching is particularly evident, where the interaction between teachers and students, classroom atmosphere, and student learning environment are very different. In this context, teachers should change their teaching philosophy from "teacher-centred" to "student-centred". They need to shift from their prominent position as the dominant force in a traditional classroom to the role of a guide, designer, organizer, and facilitator of teaching activities, create a good learning atmosphere for students, and guide them to learn independently. At the same time, students also need to transform from passive learning to active learning and self-directed inquiry-based learning and take charge of their learning in the classroom. Only in this way can the advantages of online and offline blended teaching be fully utilized and teaching tasks be better completed.

B. OBE

OBE is a student-centred and outcome-oriented teaching philosophy, as proposed by Spady [12]. This philosophy emphasizes that students must have clear learning objectives during the learning process to ensure that they can master or achieve specific skills, knowledge, and cognitive abilities. The OBE teaching philosophy focuses on learning outcomes, encouraging students to actively engage in learning and strive to achieve their desired learning outcomes.

The core idea of OBE is to employ learning outcomes as the standard for evaluating students' learning efficacy. In OBE, learning outcomes refer to the skills, knowledge, and cognitive abilities students must acquire throughout the learning process. These outcomes should be unambiguous, quantifiable, observable, and aligned with students' learning goals. OBE emphasizes amalgamating learning objectives, teaching activities, and evaluation methods to ensure students attain the predetermined learning outcomes.

To implement the OBE, collaboration and interaction between teachers and students are essential to foster autonomous learning and development. On the one hand, teachers are responsible for designing appropriate teaching activities and assessment methods based on students' learning objectives, playing the role of guide and supporter to help students achieve their learning goals. On the other hand, the OBE teaching philosophy, while emphasizing the importance of students' subjectivity and autonomy in the process of learning, also requires students to actively engage in their learning, studying hard to achieve their learning goals.

III. CHALLENGES OF IMPLEMENTING BLENDED COURSE TEACHING OF THE SYSTEM NETWORK

Although online and offline blended teaching have been popularized for many years, and the technology supporting the development of "Internet + education" has made great progress, blended course teaching on the system network still faces numerous problems and challenges.

A. Challenges of online teaching

1. When students encounter problems, although sometimes the problem is straightforward because students cannot get assistance from teachers or classmates in time, they will get stuck there, waste too much time, and even tend to give up. For example, when using Cisco Packet Tracer for simulation experiments, students may mistakenly use a "Copper Straight-Through" instead of a "Copper Cross-Over" when connecting a network to a router. This simple error may hinder students from continuing the configuration. As a result, the experiment could not be completed, and the student's learning enthusiasm was hit.

2. Online interaction between teachers and students, as well as among students, can be limited by time and space. This can lead to a lack of face-to-face interaction, emotional communication and a normal classroom learning atmosphere, resulting in a suboptimal learning experience. For example, when students encounter difficult concepts or problems, teachers cannot discover the students' doubts in time and do not re-explain or organize the discussion. This will lead to students' inability to understand and keep up with the teaching progress, resulting in fear of difficulties. For example, novice students are susceptible to misunderstandings when learning to create a subnet and calculate subnet masks using provided network prefixes. Suppose they only learn online without getting the teacher's explanation or discussing with classmates in time. In that case, they will likely fail to complete the exercises, further undermining their self-confidence in learning.

3. Because online learning often requires students to complete tasks independently, at this time, students not only need to have a certain degree of initiative and enthusiasm but also have the ability to autonomous learning and time management. Otherwise, it can decrease participation and motivation, resulting in poor online learning outcomes. The system network course covers a wide range of knowledge and concepts that are difficult to understand. The learning effect will be affected if students lack self-learning and independent study skills.

B. Challenges of offline teaching

1. Teachers need to face increasingly differentiated students. Some students with self-discipline are more conscious of learning before and after class and can even engage in self-inquiry learning. Their completion rate of online courses is relatively high. However, other students in the same class may lack proactive and learning skills. And they may not keep up with their study. As a result, teachers face students with increasingly different levels of knowledge in offline classrooms, and they feel more challenged than before during lesson preparation and teaching. For example, when preparing lessons and giving lectures, if the students' theoretical knowledge and practical skills of the data link layer and the network layer, as well as their proficiency in using the simulator to configure switches and routers, are quite different, when using real equipment for experiments in offline classes, not only do teachers need to be prepared to solve problems that may arise in the experiment before the class, but also they may need to be busy dealing with various strange problems during the class.

2. To ensure effective teaching, teachers should frequently adjust their online and offline course content and schedules and connect teaching content well. Due to the characteristics of online teaching, especially when using pre-recorded videos for teaching, teachers can often only master students' learning progress through limited access, such as homework completion and online discussions. Then, the teaching content and progress will be dynamically adjusted based on students' situations. Moreover, the system networking course covers many concepts, principles, protocols, and technologies, as well as online simulation operations and offline real device configuration operations. In addition, due to class hour limitations, the content of each class is relatively extensive. It isn't easy to adjust the content and progress frequently without affecting the teaching effect.

While implementing blended course teaching of networking, teachers usually face many other challenges not mentioned earlier. For instance, students' learning abilities are significantly different, and they need to know how to carry out hierarchical teaching effectively. Furthermore, various assessments and diversified evaluations are required while guiding students to learn independently. However, excessive evaluations increase teachers' workload, so when designing assessments, teachers need to consider making it easier to complete student evaluations while ensuring that the evaluation is as effective and reasonable as possible.

IV. Research on Strategies for Improving the Quality of Online and Offline Blended Course Teaching of System Networks with the OBE

Following the OBE philosophy, which emphasizes a student-centred and results-oriented perspective, the following strategies are proposed to address the issues that arise during online and offline blended course teaching in the system network.

A. Optimizing online and offline course content arrangements based on OBE

The course on system networks has strong applicability and technicality. By studying the course, students will achieve certain skills required for job positions. Based on the OBE teaching philosophy, the revised training plan for the network engineering major and the teaching outline of the system network course requires students to possess the capability to holistically utilize knowledge, methodologies, and technologies in addressing intricate real-world issues. Therefore, in the course teaching of system networks, the content of online and offline courses should be optimized by adhering to output-oriented education, according to cultivating skills that meet the needs of network engineering positions and combining the characteristics of course content and online and offline teaching. For example, some operational experiments, such as VLAN and routing configurations, can be completed well using simulation software and online courses. However, according to the current job requirements of system network professionals, more emphasis is placed on practical skills and problem-solving abilities. It cannot be achieved solely through simulation software operation, and offline courses need to be arranged to allow students to use real switches, routers, and other devices for experiments. Only in this way can students exercise and grow in a real practical environment, enhance their hands-on abilities, and enable the trained students to meet the job requirements well.

B. Optimizing course instruction design based on OBE

In the course teaching design, in addition to considering the course content, the characteristics of blended online and offline teaching, and integrating various teaching methods, teachers should adhere to the OBE teaching philosophy and optimize the course teaching design.

1. In course design, in addition to providing conventional teaching resources, other methods and approaches to achieve teaching objectives are also added. OBE emphasizes that different students can achieve learning outcomes through different learning processes. Students may have different methods and learning processes to achieve teaching objectives due to their varying levels of knowledge. Moreover, even if teachers can provide as many resources as possible, it may not necessarily meet the needs of students at different levels. Therefore, by providing methods and pathways to achieve teaching objectives, students are guided to explore and learn independently, allowing different students to find suitable paths for their success. For example, the switch configuration operation can be recorded in a video. Still, it is possible that the explanation of the operation process in the video may not stimulate the learning interest of all students. In this case, adding guidance on other learning pathways in teaching design will greatly meet the needs of more students.

2. OBE emphasizes the importance of practical learning. Therefore, teaching designs in both online and offline settings should incorporate practical knowledge, and this can stimulate students' learning interest and enhance their ability to utilize knowledge. For example, after completing the experiment of making twisted-pair cable, teachers can guide students on selecting it on online shopping platforms and even purchase production materials and tools to make it and sell it to students in other majors. Similarly, after completing the fiber optic cold connection experiment, teachers can guide students on how to carry out fiber optic or twisted-pair cable wiring while decorating new houses. Furthermore, after learning the working principles of modems, switches, and routers, teachers can guide students on choosing and purchasing home routers, cable modems, or power line modems. Teachers can also provide instructions on choosing an internet service provider (ISP) and purchasing household routers and required cables to complete the entire project of home networking. These practices can help students better understand their learning content and increase their enthusiasm for learning.

3. In the course teaching design, some content can be designed to be learned through group collaboration, and it will be emphasized that all members must participate. The system network course involves vast knowledge with high comprehension difficulty and complex practical hands-on skills, which require a long time to master. It can be challenging for students to achieve the designated learning objectives solely based on their efforts. To address this challenge, difficult theoretical knowledge, such as routing algorithms, congestion control, and so on, can be assigned to group discussions to enhance their understanding. Moreover,

group experiments can reduce experimental time while enhancing students' confidence in learning, communication, and exchange among classmates.

C. Improving course evaluation approaches based on OBE

Based on the OBE teaching philosophy, evaluating learning outcomes is crucial. Many teachers propose to focus on process evaluation and increase effective diversified evaluations, which are very good practices. However, to implement these evaluations, teachers need to plan and develop reasonable evaluation standards, which will be time-consuming for teachers and may hinder them from promoting these assessments. Some conventional assessment items, such as homework and experiments, are proposed to be reformed In the following text while appropriately adding some evaluation items. This paper proposes to reform the completion and evaluation methods of routine assessment items such as homework and experiments while appropriately adding some evaluation items, as well as to change the evaluation from an individual to a group for some tasks. These reforms improve evaluation effectiveness and help students complete various learning tasks. Furthermore, these reforms also reduce teachers' workload and increase their enthusiasm for promoting these evaluations.

1. General homework is usually evaluated based on handwritten assignments. We propose a reform in the form of homework, where students can also submit individual or group recorded audio or video. Voice or video can be the answer to the exercise, the method of solving the exercise or the analysis of key points. In general, when students do homework, they mostly search for information or answers online to copy, which means they do not think seriously while solving problems, so their mastery of knowledge is not deep enough. However, if the submitted homework is in voice or video, students must think carefully and prepare to grasp the knowledge better. In addition, if the submitted homework is a voice or video of a group discussion, it will no longer be as monotonous as before, where students can interact and learn from each other during the discussion process, stimulate learning inspiration, and promote collective learning. Moreover, compared to reviewing handwritten assignments, audio or video can make it easier and clearer for teachers to master students' mastery of knowledge. In addition, as each group only submits one assignment, the number of assignments evaluated by teachers is greatly reduced, and the workload will not increase too much.

2. Generally, experiments are evaluated based on textual experimental reports. We advocate a formal reform where students submit individual or group recorded videos simultaneously. The recorded video includes experimental principles, experimental processes, and experimental analysis. Students are encouraged to complete experiments in groups. Most system network course experiments, such as twisted pair production, fiber optic cold connection, VLAN configuration, subnet partitioning, etc., are very suitable for group experiments. After submitting the experiment, teachers can select some excellent works to publish on the online teaching platform and encourage students to post the recorded videos on the short video platform for communication and learning. This not only enables students to continuously understand and master experimental principles and operational skills throughout the entire experimental process but also greatly stimulates their initiative and enthusiasm to participate in the experiment.

3. We institute that some learning tasks, such as written assignments, experiments, study reports, etc., can be completed by groups instead of individuals. Online learning may make students less proactive. One reason is that the theoretical knowledge of system networks is relatively extensive and difficult to understand. On the other hand, the lack of immediate interaction between teachers and students in online courses and among classmates leads to students not receiving timely help. OBE advocates collaborative learning, which can provide students with an environment for mutual learning and communication, which is one of the very effective approaches to solving these issues. By changing the evaluation methods, students are encouraged to form study groups and collaborate at appropriate times and places to discuss and solve problems. This can compensate for the lack of classroom atmosphere and enhance learning confidence. In an implementation, it is necessary to guide students to establish a collective concept and sense of responsibility, clarify the goals that the group and each member need to achieve, improve their understanding of collective honor, and stimulate their learning interest and initiative.

V. System Networks Outcome

Since 2019, the Guangdong School of Computer Science has revised the curriculum by changing from the traditional approach-based curriculum and textbook to the approach with the OBE for various majors. In recent years, the teaching syllabus has been continuously improved through in-depth learning of OBE philosophy and continuous exploration in teaching practice. After years of teaching practice, the course on system networks has better aligned with the OBE philosophy, and the teaching quality and student satisfaction have continuously improved. Despite the epidemic's impact, many difficulties have been encountered in blended online and offline teaching, and we adhere to the OBE teaching philosophy. Moreover, the teaching research results proposed in this paper have been extended to the routing and switching technology course, laying a solid professional foundation for students majoring in network engineering. Before we conclude, we review the early approaches and their outcome.

The primary goal of the OBE is to implement reforms by enhancing responsibility while supporting greater independence or adaptability in teaching models using network systems, as confirmed by numerous research findings. [13, 14, 15]. The Washington Accord was issued to implement the OBE framework for higher education engineering courses that meet the standards set by the OBE and its directives. [16] It has been emphasised that the dedication to ongoing quality enhancement (OQI) to complete the cycle via efficient feedback guarantees that the intended results are achieved to everyone's satisfaction and that the procedure is consistently and continuously improving. [17] Two outcome-based network visualisations were synthesised using network analysis and came with the deliverables. [18] A framework for setting up and building the artificial neural network to evaluate individual accomplishments through fuzzy simulation has been established, and it can serve as a lead in future models. [19]

VI. Conclusion

This paper analyzes the problems encountered during blended online and offline teaching in system network courses. It also proposes some teaching quality improvement strategies based on OBE to solve these problems. These strategies include optimizing the online and offline course content and teaching design and improving course evaluation approaches. The results of teaching practice have shown that the proposed strategies can effectively stimulate students' learning interests and improve student's learning outcomes and teaching quality.

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