Reform and Exploration of Output-oriented Integrated Teaching of Principles of Operating System Course

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Abstract—Students' learning initiative and cognitive participation in traditional offline teaching of Principles of Operating System course are not high, and it is not easy to effectively analyze and timely feedback students' learning situation. Based on output and combined with MOOCs, Rain Classroom and other teaching platforms, integrated teaching reform and exploration about Principles of Operating System course is carried out, so as to improve students' classroom participation, enhance students' active learning, and the ability of thinking, analyzing and solving some related problems in software engineering, and advance in teaching quality.

Keywords-output-oriented; integrated method; teaching reform about Principles of Operating System course; teaching quality

1. INTRODUCTION

Principles of Operating System is a basic compulsory course for undergraduates in our School of Software Engineering. This course aims to train students to have a comprehensive understanding of the Operating System (OS), master system software and concurrent programming methods, and have the ability to use the OS platform to analyze and solve practical problems, as well as software design and development. This course involves many theories and abstract contents, so it is difficult to learn this course well.

With the rapid development of Internet and the widespread applications of various smart phones, smart tablets and personal computers, it has brought great convenience and rapidity to people's life, work and study. But all kinds of fun games, diverse long videos, short videos, online news and so on are easy to attract people, especially some college students, and may even distract their attention and interest in learning. Some problems in traditional classroom teaching of Principles of Operating System are as follows:

(1) It is not easy to learn this course well, and some students do not realize the importance of this course. Basic principles, main functions and implementation mechanisms of computer OS will be systematically explained in this course. Prerequisite courses include Computer Composition Principles, Data Structures, and some basic programming courses. In addition, students are

ITEI 2023, November 24-26, Zhengzhou, People's Republic of China

DOI 10.4108/eai.24-11-2023.2343655

required to have some knowledge such as logical address, physical address and memory. It has certain difficulty in learning the course well because of many theories, abstract contents and knowledge correlations. Besides, unlike other programming languages (such as C, Java, etc.) and Database course have immediate programming effect and experience. Therefore, some students are not very interested in learning this course and are easy to ignore its importance.

(2) Teaching method is single, students' learning initiative is not high, and the cognitive participations are insufficient. Traditional teaching is teacher-oriented, and students are passive learners most of the time, which makes the multifaceted contents of Principles of Operating System seem more boring and difficult to understand.

(3) The class hours are 48 in total, so the time for interactions, discussions and practices in class is relatively tight, resulting in insufficient time for students to actively think and analyze. Meanwhile, the location and time of face-to-face teaching are limited, consequently some students have difficulty in understanding parts of internal logic and implementation mechanism of the OS.

(4) It is difficult to track and analyze all students' learning in time during the teaching. Students lack the awareness of active learning, and the training of students' ability to think, analyze and solve complex problems needs to be enhanced.

Online teaching is flexible and not subject to geographical restrictions. Students can complete learning tasks as long as they have access to the Internet with a smart phone or a smart tablet or a personal computer. There are also plenty of online resources and students can study independently at any time. Teachers can also select, integrate or reorganize online resources. Meanwhile, various online platforms such as Rain Classroom, Ding Talk, Tencent Conference, etc., have also been rapidly developed in recent years, making teaching more convenient and easier for teaching data collection, analysis and statistics, which is more helpful for teachers to know and assess students' learning. Comparatively, traditional offline classroom teaching can provide more intuitive, vivid, cordial and warm communications, interactions and discussions. For example, when discussing why to learn the OS, what are the current popular operating systems on personal computers and mobile phones, teachers and students feel more directly and warmly, the classroom learning atmosphere is more active, and the team discussion is more convenient. Additionally, offline classroom teaching is better for teachers to observe the learning state of students in class, and adjust classroom teaching more conveniently and timely. Online teaching and traditional offline teaching have their own advantages, and students-centered [1-2] blended teaching [1,3-9] has been developing continuously in many colleges and universities.

With the continuous development of the Internet and information-based education reform in China, various online teaching platforms, MOOCs, micro-courses and other models are also emerging and growing. In the context of Outcome Based Education (OBE) [2,7,9-11], combined with some online platforms and MOOCs, the reform and exploration of integrated teaching about Principles of Operating System course in our school has been gradually carried out, which has certain educational value for advancing students' learning participation enthusiasm, cultivating students' thinking, as well as their ability to study independently and analyze problems.

2. METHODS OF TEACHING REFORM AND EXPLORATION

2.1 Online autonomous learning

The online resources of this course mainly refer to the MOOCs provided by the book Computer Operating System (MOOCS Edition) edited by Tang Xiaodan et al. Students can learn online contents independently in their spare time through personal computers, laptops or various smart devices (such as smart phones, smart tablet computers, etc.) in a more flexible and convenient way, and then enter the class with questions. For main and difficult knowledge, the book also has micro-lesson resources to help students thoroughly understand some of the core principles and mechanisms of OS. Students can also review the classroom knowledge after class and make up for the gaps or self-study in advance.

2.2 Construction of online question bank and tests

Rain Classroom and sojump are used in our course. In the Rain Classroom platform, part of the question bank is built first, and the online tests are set for some teaching chapters. After the students pass the online tests, students' scores are calculated automatically, and teachers can conveniently check and know students' mastery of relevant knowledge, so as to timely adjust teaching designs. At the same time, Rain Classroom and sojump tools are used to construct some in-class tests and practices, which are mainly used for online teaching during face-to-face classroom teaching. In addition, sojump is also used to design students' questionnaires related to the teaching of this course and supervise the results, helping teachers to understand the teaching situation and adjust the course implementation plan, sequentially improve the teaching quality.

2.3 Integrated classroom teaching

1) Online classroom teaching

In face-to-face classroom teaching, for improving students' participation in class, testing students' mastery of knowledge points and consolidating what they have learned, some relevant online exercises, extended tests and time-timed answer are set up for students, aiming at the important and difficult points and some knowledge that students are prone to make mistakes in learning. Then the teacher or some students named randomly will timely comment on the questions on the spot. For example, before learning the concept of OS, some online exercises will be set in the classroom, including a multiple-choice exercise "Which of the following are operating systems?" is shown in Fig. 1.

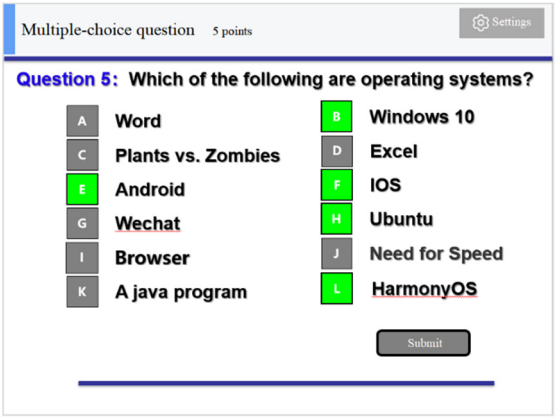

Figure 1. A multiple-choice exercise.

In addition, to stimulate students' innovative thinking and learning passion, HarmonyOS, Ubuntu, Android etc. are also introduced here.

2) Diversified offline teaching

Combined with some online classroom teaching, offline teaching in class also mainly adopts diversified teaching methods such as problem-oriented, flipped classroom and so on. The diversified teaching methods used in different teaching contents are slightly different, but mainly include case teaching, question guidance, random roll call and questioning, consolidation and extension exercises, class discussion, flipped classroom, decomposed teaching, animation demonstration and other methods. For instance, in learning the short-process priority scheduling algorithm, the diversified blended methods used are:

a. Classroom exercises: Review FCFS algorithm through 1 multiple choice question, 1 fill-in-the-blank question and 1 true or false question;

b. Problem guidance and teaching: What is the non-preemptive short process priority scheduling algorithm?

c. Case teaching: "If 5 processes need to be scheduled and the non-preemptive short process priority scheduling algorithm is adopted, please draw the process running sequence diagram, and calculate the average turnaround time and average weighted turnaround time respectively." as an example. Diversified teaching methods are:

Decomposition teaching: The scheduling execution of 5 processes is decomposed into multiple scheduling choices. Divide the problem into smaller steps and solve it.

Question guidance and random roll call: at each time of scheduling selection, think and answer:

① What processes are currently in the system?

② What is the queue of processes in the ready queue?

③ Which process is chosen to execute?

④ Why is this process selected for execution?

⑤ After a process executes, what is the start time and finish time of the process?

Animated presentation: Draws the selected process execution line segment.

Think and Discuss: If other processes arrive in the system during the execution of a process, does preemptive scheduling happen immediately?

Question guidance and random roll call:

① What is turnaround time?

② What is weighted turnaround time?

③ In this example, what is the formula for calculating the turnaround time of each process?

④ What is the formula for calculating the weighted turnaround time of a process?

Class exercises and random roll calls:

① Please calculate the turnaround time and weighted turnaround time for each process.

② What is the average turnaround time and average weighted turnaround time respectively?

d. Think and discuss: What is the difficulty of this algorithm?

e. Comparison exercise: FCFS scheduling algorithm practice.

f. Flipped classroom: A students is randomly selected for addressing the comparison exercise.

g. Discuss: Disadvantages of the short process scheduling algorithm.

h. Consolidate and expand exercises: complete other exercises of non-preemptive short process priority scheduling algorithm in class.

i. After-class exercises and MOOCs learning: complete the assigned homework, and conduct independent MOOCs learning of other scheduling algorithms.

2.4 Improve teaching based on outcome

Teachers could adjust teaching plans and methods according to the results of online tests, classroom practices, after-class exercises, and class participation, etc., aiming at students' error-prone points, and further consolidate relevant contents in classroom teaching. For example, in learning ‘semaphore and using semaphore to solve process synchronization problem and other contents’, students have a certain difficulty in understanding and mastering these contents. During classroom teaching, some online tests or extended practices will be added accordingly. One online classroom exercise is shown in Fig. 2.

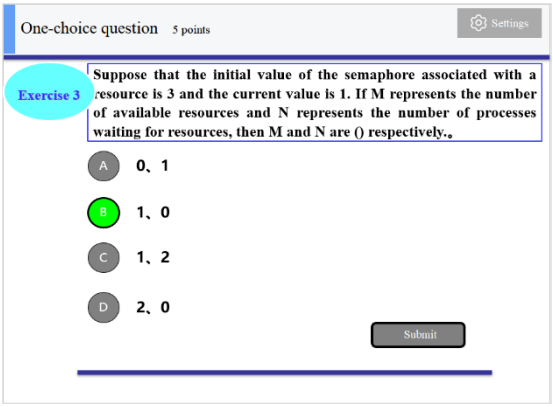

Figure 2. One online classroom exercise.

Other supplementary extension exercises such as: the problem of putting (taking) fruit among dad, son and daughter on a plate, cross the log bridge problem, single-lane problem, limited bridge problem and so on. Please think and try development exercises as well after class: barber shop, ticket hall, reading room and other synchronous problems; complete homework, and learn MOOCs. In addition, some extracurricular computer practices, such as trying to program and implement three classic synchronization problems, so as to better understand these abstract contents.

2.5 Multifarious assessment and evaluation

The process analysis of this course includes online chapter tests, attendance and class participation, random questions in class, class tests or exercises, homework, questionnaire survey and statistics, etc. Meanwhile, students' learning situation can also be understood and analyzed with classroom discussion and flipped classroom. Combined with the final examination, the students' ability achievement could be analyzed, which provides the basis for the continuous improvement of the teaching quality.

3. Results and Discussion

With regard to online classroom teaching, for instance, the answer statistic and distribution as for a multiple-choice online exercise "Which of the following are operating systems?" are shown in Fig. 3 and Fig. 4 respectively.

Figure 3. An answer statistic.

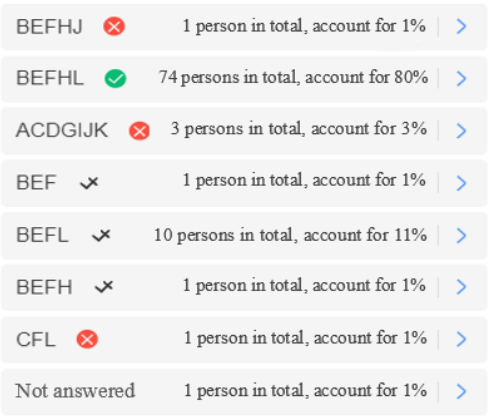

Figure 4. An answer distribution.

According to the statistical results, the teacher or some students named randomly would timely comment on the question and answers. This kind of online exercise or test, online timed answer and timely evaluation can not only improve students' participation in class, but also test students' mastery of some knowledge points and consolidate what they have learned. Besides, the introductions of HarmonyOS, Android, Ubuntu, Linux are also interspersed here to inspire students' enthusiasm for learning and innovative thinking.

As regards diversified offline teaching, for instance, when learning the short-process priority scheduling algorithm, the detail design of the diversified blended methods used could be seen from the previous description of section C in chapter II. Diversified teaching is student-centered, which could exercise students' ability to analyze and solve problems, train their thinking and expression skills, and stimulate students' learning enthusiasm and interest.

In the questionnaire survey, such as course objective 2: some synchronization problems with concurrent execution of multiple processes (or threads) in software engineering could be solved by using the solutions to the classical process synchronization problems, the statistics are shown in Fig. 5.

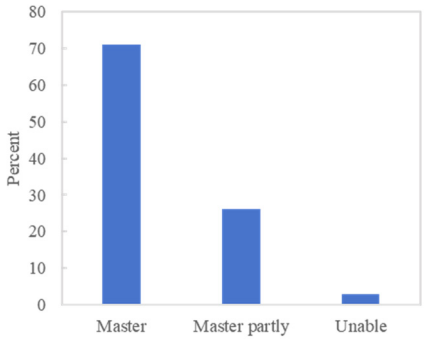

Figure 5. The statistics of objective 2.

From Fig. 5, most students could understand and master some synchronization problems of concurrent execution.

In the final exam, the correspondence between the score of knowledge points and each course objective is shown in table 1.

Table 1. Correspondence between knowledge score and course objective

objective	1	2	3	4	5	6
score of knowledge points	7.5	15	5.5	17.5	42	12.5

The average score of each course objective in an integrated teaching class and a traditional teaching class is shown in Fig. 6.

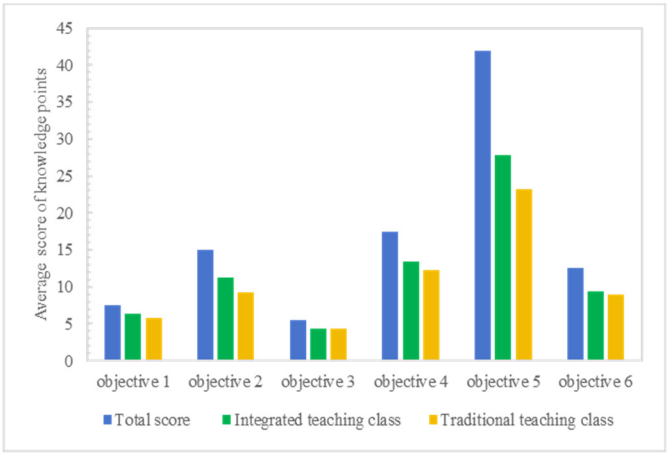

Figure 6. The average score of each course objective in two classes

The average score of each course objective in an integrated teaching class and all classes of a software engineering major is shown in Fig. 7.

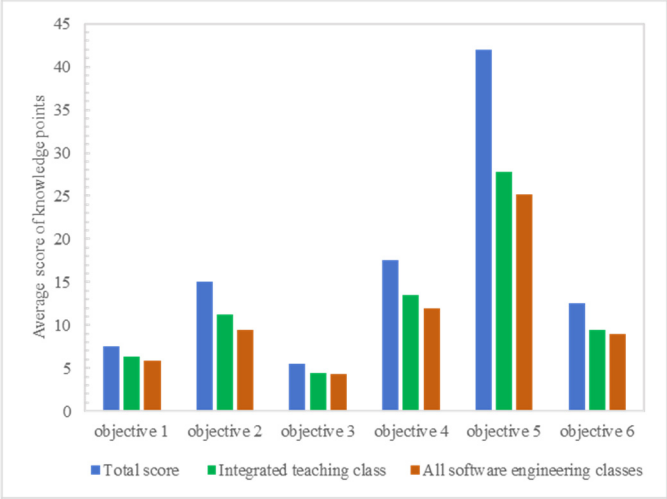

Figure 7. The average score of each course objective in a class and a major

From Fig. 6 and Fig. 7, the final average score of each course objective in an integrated teaching class is higher than a traditional teaching class and all classes of the software engineering major.

The score distribution of final exam in an integrated teaching class and a traditional teaching class is shown in Fig. 8.

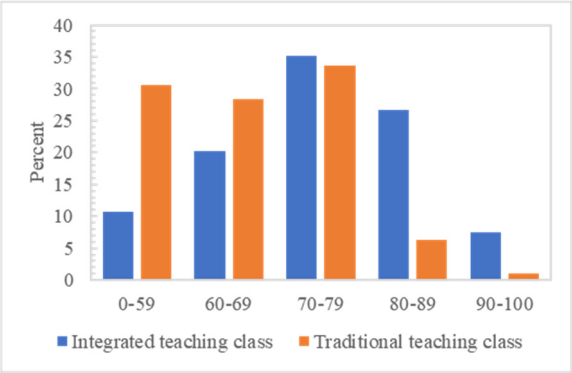

Figure 8. The final score distribution.

As can be seen from Fig. 8, in the integrated teaching class, the proportion of students who scored 70-79, 80-89 and 90-100 at the end of the semester was higher than that of the traditional teaching class, while the proportion of students who scored 0-59 was lower than that of the traditional teaching class. Integrated teaching is easier to improve students' understanding and mastery of teaching content, as well as their ability to analyze and solve problems.

4. CONCLUSIONS

The integrated and diversified teaching reform and exploration of Principles of Operating System course have greatly changed the classroom teaching effect. Students' participation in class has been greatly improved, the classroom teaching atmosphere has become more active, and students' learning attitude has also changed significantly, which has also played a good impact on stimulating students' self-directed learning and self-improvement. Likewise, some contents, such as online question bank, experimental projects and quality education, are still being built and explored to provide support for training students' ability and letting students get a better sense of achievement in learning.

Acknowledgment: Undergraduate education and teaching research and reform project and undergraduate teaching engineering project of CUIT in 2022 (JYJG2022050), and 2023(JYJG2023187).

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