Exploration of Software Engineering Instructional Model Based on the Integration of OBE and BOPPPS

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Abstract. To address the problems in the traditional teaching of *Software Engineering* course, this paper analyses the connotations of the *OBE* education concept and the *BOPPPS* model, and proposes the integration of both of them into the *Software Engineering* instructional model and its teaching design. The original *BOPPPS* model is improved to be more in line with the requirements of the discipline and the curriculum. Then specific implementation methods and operations are given for each of its teaching modules. Finally, an OBE-based evaluation method for the achievement of course objectives is presented. The proposed instructional model provides a complete set of reference programmes for practical teaching activities, which help students to obtain better results and improve their overall competence.

Keywords: OBE; BOPPPS; Software Engineering

1 Introduction

Software Engineering is a professional core course for Software Engineering majors, providing basic support for *Software Analysis and Design*, *Software Testing* and other courses. Through this course, students should be able to develop an engineering mindset, master the software development process and common software analysis and design techniques, and have the ability to use software engineering tools [1]. Software Engineering is taught to sophomore undergraduates. Most of them have certain programming foundation, but lack engineering thinking and the ability to solve complex engineering problems systematically. The *Software Engineering* course has a lot of abstract theoretical knowledge points, which makes many students feel intimidated. In addition, students' learning objectives are not clear, and their independent learning and enthusiasm are relatively poor. As a professional core course, the existing teaching approaches have various defects: the teaching mode is still teacher-led, not student-centered, and cannot effectively stimulate students' enthusiasm; the flipped classroom cannot track students' learning situation in real time [2] [3]. As a result, students cannot have fun in learning, and the existing instructional model cannot meet the need of cultivating a large number of application-oriented innovative talents nowadays.

The international accreditation of engineering education has become a new direction for the reform and development of engineering education in Chinese universities. Outcome-Based Education (OBE) has pointed out the direction to solve the problem of disconnection between talent cultivation and social needs in domestic universities and has attracted wide attention from the education area [4]. BOPPPS teaching model focuses on interactions and reflections, and

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emphasizes students' participatory learning, which truly embodies the idea of taking students as the main body [5]. At the same time it is recognised for its ability to facilitate the design of classroom sessions and improve the quality of teaching and learning [6]. Therefore, this paper explores the integration of OBE and BOPPPS model into the teaching and practice of *Software Engineering* course.

2 OBE education concept and BOPPPS model

Engineering education accreditation is not only the guarantee of engineering education quality, but also the basis for mutual recognition of technical qualification of engineering personnel and engineering education level in the international arena, which has become a new direction for the reform and development of engineering education in Chinese universities. OBE is an educational model to cultivate students' knowledge, ability and quality needed to obtain results. The application of OBE to curriculum reform and practice has become an important issue to be solved by teachers and managers in Chinese universities.

BOPPPS is an effective curriculum design model. The main features of BOPPPS include the emphasis on participatory learning methods, clear teaching objectives and teaching objects, and effective analysis of students' mastery and application of knowledge [7]. It modularizes the teaching process, including 6 modules directly corresponding to the teaching process [8]. So the BOPPPS model is generally recognized as composed of 6 stages: *bridge-in*, *objective*, *pre-assessment*, *participatory learning*, *post-assessment* and *summary*. BOPPPS helps teachers to organize teaching, analyze the teaching process and discover blind spots. It also helps students to understand knowledge, improve their interest in learning [9]. Thus, both teaching quality and learning effectiveness can be improved. The BOPPPS model is found to be similar to the OBE concept and helps students acquire the knowledge, abilities and qualities needed for results [10].

3 Software Engineering instructional model based on the integration of OBE and BOPPPS

3.1 Improved BOPPPS model

In consideration of the characteristics of Software Engineering discipline and the limited teaching hours, we have improved the original BOPPPS model and adjusted the operation sequence in the original model to make it more in line with the requirements of this discipline and curriculum. The improved instructional model is shown in Fig. 1, with *pre-assessment* implemented in advance. *Pre-assessment* of the next class is posted to the online platform for students to answer in advance after the previous class. This improvement enables teachers to know students' knowledge base in advance and to design the class well.

In the teaching process, *objective*, *pre-assessment* and *post-assessment* are arranged in the online environment of our cloud platform. *Objective* is the basis for the design of *pre-assessment*, and *pre-assessment* is a concrete form of learning analysis to achieve the *objective*, which is the preparation for achieving *objective*. *Post-assessment* is a test of the participatory learning process. *Bridge-in*, *participatory learning*, and *summary* take place in classroom.

Bridge-in is the prerequisite and foundation of *participatory learning*, and *summary* is the condensation and enhancement of the entire learning process. The combination of online and offline allows the single synchronous classroom interaction to be extended to a combination of synchronous classroom interaction and asynchronous online interaction. In this way, teachers are able to understand students' foundations and learning outcomes, and then adjust the level of difficulty of the knowledge taught accordingly, and adopt more targeted teaching techniques to complete teaching, thus achieving effective teaching.

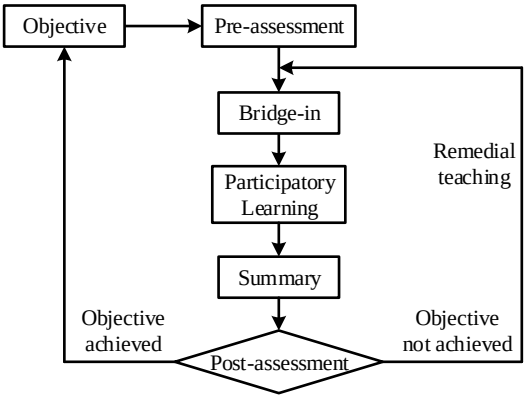

Fig. 1. Improved BOPPPS instructional model

3.2 Instructional design based on OBE and BOPPPS

The main tasks of each module of the improved BOPPPS model and their implementation forms and delivery places are shown in Table 1. Based on it, the Software Engineering instructional design methodology and process that integrates OBE and BOPPPS is described as follows.

Table 1. Main tasks of each module and their implementation form and delivery place in the improved BOPPPS model

No.	Module	Main Tasks	Form	Delivery Place
1	Objective	Clarify teaching objectives (or learning objectives)	Announcements in text form with specific, clear, measurable words	Cloud platform
2	Pre-assessment	Understand students' prior knowledge and abilities	Statistics of autonomous learning tasks, assignment exercises corresponding to the knowledge points of the teaching videos	Cloud platform
3	Bridge-in	Guide students to think and start teaching	Introduction with inspiring questions or practical examples	Offline class
4	Participatory learning	Adopt positive learning strategies to make students deeply participate in classroom teaching	Teacher questions, class exercises, knowledge competitions, case studies, group discussions, teacher-student discussions, and student mutual evaluations.	Offline class
5	Summary	Summarize and conclude the teaching contents	Summarizing, condensing, generalizing and expanding	Offline class
6	Post-assessment	Check the completion of students' learning objectives and assess the	Objective-specific quizzes and homework	Cloud platform

		effectiveness of class teaching		

Objective (O): Objectives are both the goals of student learning and the basis for teacher teaching, as well as the criteria for learning effect assessment. According to the OBE concept, we set the teaching objectives (including knowledge objectives, ability objectives and quality objectives) of this course according to the practical application ability that students should acquire, and organize and refine them into specific, clear and observable or measurable class objectives, which are a set of statements based on clearly measurable vocabulary such as *express*, *describe*, *analyse*, *design* and *develop*. The class objectives are then used to design the corresponding teaching methods and means in reverse. In the online environment, class objectives can be presented in the form of text. As the class is often taught in a large number of learners, the objectives need to be clearly communicated to all students, so they are considered to be presented in the form of announcements in order to guide students to carry out their own learning plans based on the objectives and to better grasp the important and difficult points in learning.

Pre-assessment (P): Pre-assessment is a comprehensive analysis of the learning situation, teaching content and class objectives to determine the students' situation and understand their mastery of basic knowledge so that they can be taught according to their abilities. It provides the basis for the follow-up activities. OBE advocates the achievement of learning objectives for each student through the whole teaching process. However, each student has different knowledge basis and competence. Teachers can only adapt the follow-up teaching arrangements (such as weight, difficulty, and pace of instruction) once they know the learning situation of each student. Teachers make independent learning checklist before class and post learning tasks and related teaching videos on the cloud platform. Students study the videos online. After learning the video there are homework exercises corresponding to the knowledge points for pre-assessment. Teachers use the exercises to test students' learning of the videos and their knowledge, and to discover deviations in students' knowledge learning so that they can grasp the important and difficult points of teaching contents in the preparation stage and fill in the gaps in subsequent classroom teaching.

Bridge-in (B): Bridge-in is to explain the connection between the class objectives and the learning content, the learning ideas needed to achieve the goals, to arouse students' interest in learning, and to lead them to think about the course content. Teachers need to design the *bridge-in* content, select practical application problems or cases to introduce the teaching content and stimulate students' interest. The common methods for designing *bridge-in* include problem introduction and case introduction. Problem introduction is the activity where teachers design relevant questions based on the teaching content and objectives to guide students to think and start teaching. The questions should be moderately difficult, closely related to the class content, and inspire students to think, so as to increase students' participation in the teaching process and stimulate their curiosity. For example, new knowledge about the types of requirements and the methods of obtaining them can be introduced by asking questions such as "What are the requirements of the book sales app to be developed" and "How to get the requirements of this book sales app". Case introduction is to create a situation with a specific case and present the teaching content by analyzing the knowledge used in a life case, which can easily trigger students' empathy and stimulate their awareness of active and deep participation in the learning process.

Participatory learning (P): The concept of OBE tells us that learning effectiveness is evaluated by how much students have learned rather than how much teachers have taught. Therefore, *participatory learning* mainly adopts active learning strategies to make students deeply involved in classroom teaching, with the aim of keeping students interested in learning and enthusiastic about learning, and being able to continuously explore so as to achieve their learning goals. Before each offline class, teachers use the cloud platform to collect independent learning data, including pre-class video viewing and knowledge quiz scores, to keep track of students' learning trends before class through data analysis. The main problems in independent learning are taken as the main points of classroom teaching objectives in each lesson. Classroom activities are designed around the existing problems, teaching objectives, and knowledge points. *Participatory learning* can be organized in various forms, including teacher questions, class exercises, knowledge competitions, case studies, group discussions, teacher-student discussions, and student mutual evaluations. For example, in order to consolidate basic knowledge, teaching activities in class can be organized in the form of knowledge competitions, which are designed according to the order of knowledge points, from easy to difficult. For the important points, teachers can first lecture on the knowledge points with the help of information technology, or design difficult questions to encourage teachers and students to discuss and deepen students' understanding of the knowledge. For project tasks, in addition to teachers' introduction of the main tasks and priorities of each stage for different stages of the software development process, each team should also conduct a brief analysis of the current stage of the work schedule and the problems that exist. Discussing among groups as well as between teachers and students can help the groups to clarify the exact tasks of the current phase and to revise the project plan.

Summary (S): In the *summary* stage, briefly summarize the teaching content of the class, condense the teaching results of the lesson, summarize all the knowledge points, analyze the problems that occurred during the learning process, point out the thinking methods to solve the difficult points and key points, expand the application fields of knowledge, help students integrate theoretical and practical relationships, and guide them to reflect on the content and further investigate and learn the content in depth.

Post-assessment (P): Post-assessment evaluates the effectiveness of classroom teaching activities, tests whether students can achieve the learning objectives proposed by applying the OBE concept, detects whether students' ability to understand and apply knowledge is achieved, and verifies whether the whole classroom teaching is effective. By comparing the results of *post-assessment* with the objectives, the shortcomings in students' knowledge can be summarized, so that teachers can review their whole teaching process, adjust the teaching strategies and optimize the subsequent teaching design. *Post-assessment* is arranged to be done after class and is conducted through the quiz and homework functions of the cloud platform. Its content should reflect the students' mastery of the class objectives, and at the same time consider how the students apply their knowledge to solve practical problems after learning. Test items can be designed for different objectives to assess the learning effect from different aspects. If students have questions about theoretical knowledge, they can watch videos and consult materials online at any time for learning, and communicate with teachers online through the course cloud platform. For project practice, students are required to work in teams to complete phased tasks (e.g., project requirements report, overall design, detailed design, database design, interface design, etc.) and submit them online for teachers‘ review, so

that teachers can keep track of students' understanding and mastery of knowledge and skills and then adjust their teaching.

3.3 OBE based evaluation of course objective achievement

OBE-based course objective achievement evaluation refers to the evaluation of the extent to which the course objectives designed by teachers based on OBE ideas can be achieved in the teaching implementation process. The objective achievement evaluation of Software Engineering course is mainly conducted through the process assessment performance analysis. This method is mainly based on students' various online and offline exercises, quizzes, experiments and assignments in this semester's course, as well as the results of the final exam. The degree of achievement of each student's course objectives is equal to the percentage of the total number of points that the student scored for each objective. And the overall course objective achievement is the arithmetic mean of each student's course objective achievement. The calculation method is shown in Equation (1).

$$P(o_i) = \frac{1}{N}\sum_{j=1}^{N}\frac{\sum_{k=1}^{n}\varphi_k^{ij}}{M_j} \tag{1}$$

Here, o_i is the ith course objective, N is the total number of students, o_i has a total of n scoring items in each grade, φ_k^{ij} is the score of the jth student on the kth scoring item, and M is the total score that the student should get on all scoring items.

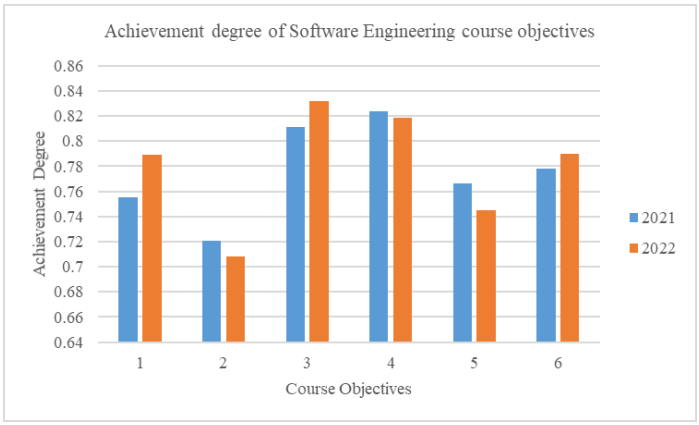

Fig. 2. Example of OBE based course objective achievement

Fig. 2 shows the results of the evaluation of Software Engineering majors' achievement of Software Engineering course objectives in 2021 and 2022 obtained by using the above statistical method. The data and various supporting materials used in the statistics come from the relevant exercises, tests, experiments and assignments on our cloud platform and offline classes, as well as the results of the final examination. From the figure, it can be seen that all the course objectives of the Software Engineering course have reached 0.7 or above. Course Objective 3 and 4 were achieved better than the other objectives. This indicates that the teaching has a significant effect on the development of structured and object-oriented analysis and design skills.

4 Conclusion

In order to implement OBE into the course teaching, this paper proposes to apply the BOPPPS model to the Software Engineering course. The original BOPPPS model was improved according to the characteristics of the Software Engineering discipline and the actual situation of teaching resources in our university. The order of operations in the original model was adjusted and the six modules of BOPPPS were assigned to both online and offline classroom environments in order to better match the requirements of the subject and the course. The model provides a complete set of reference solutions for practical teaching and learning activities, helping students to achieve better results and improve their overall competence.

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