Application of Blended Teaching in Software Architecture for Graduate Students

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Abstract. Software Architecture for graduate students has characteristics of high degree of abstraction, complex content and strong practice. According to these characteristics, teaching concept of BOPPPS is introduced into the course blended teaching. Six links of BOPPPS are identified as the introduction (Bridgein), Objective (Objective), Pre-assessment, interactive Learning, Post-assessment and Summary (Summary). The relationship between these links and the three stages of blended teaching, namely before class, during class and after class, is made clear. A hybrid teaching model based on BOPPPS is established, and the application of the model in Software Architecture is illustrated taking the design driven by key quality attributes as an example. The practice shows that the blended teaching based on BOPPPS improves students' enthusiasm and interest in teaching, and then promotes the improvement of teaching quality and the achievement of teaching objectives.

Keywords: Software Architecture · Blended Teaching · BOPPPS · Attribute Driven Design

1 Introduction

Software Architecture is a core course for software engineering graduate students. This course focuses on the basic components of software systems, the external characteristics of the elements and the interrelations between the elements. It is a course about the design and analysis about the overall high-rise structure of complex software systems [1]. Under the background of increasingly large and complex software scale, it has become a consensus in academia and industry that software architecture is used to realize important design decisions of the system, so as to ensure the complete, highly consistent and forward-looking design and implementation of the system to meet needs of users. The purpose of offering Software Architecture at the postgraduate stage is to enable students to conceptually establish the concept of software system from the perspective of architecture, understand the influence of the pros and cons of architecture design on the quality of software system, master the basic knowledge theory and related skills of software architecture practice, as well as the architecture skills required by the industry, and lay a foundation for the training of software architects.

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Software Architecture has the characteristics of high degree of abstract content, complex content and strong practice. Students learn difficult, and learning effect is not obvious. Therefore, combining with the actual situation, it is of great significance to carry out the teaching reform for improving the teaching quality, achieving the curriculum objectives and cultivating students' ability. Y. Shen et al. [2] proposed the course construction scheme of Software Architecture for graduate students from three aspects, including course teaching content, course practice project and teaching effect evaluation. Z. G. Ding [3] took task-driven as the main line and applied the teaching method of flipped classroom in Software Architecture teaching. J. J. Huang et al. [4] applied the penetrating case practice teaching method in the teaching of Software Architecture. Y. S. Lin et al. [5] carried out teaching exploration and practice of Software Architecture based on learning and mutual assistance. Q. Zhou et al. [6] applied the theory of learning transfer to Software Architecture teaching; J. Ding [7] studied the teaching method of software architecture based on agile development. T. Li et al. [8] proposed and implemented a teaching program of Software Architecture based on case-based teaching, flipped classroom and open source software. G. P. Li et al. [9] studied the ecological classroom design of Software Architecture based on the constructed alliance teaching method. Y. Sun [10] et al. proposed and practiced the course construction idea of Software Architecture based on real project cases, which combined with the concept of OBE. However, on the whole, the current researches were mainly carried out for undergraduate courses, and the teaching research and practice of Software Architecture for graduate students are still insufficient.

Blended teaching is a new teaching mode, which comprehensively uses different teaching theories, techniques and methods [11]. Blended teaching plays an important role in reconstructing traditional classroom, expanding teaching time and space, and cultivating students' ability. In recent years, with the rise of MOOC, online-offline blended teaching has been widely used in China and achieved good results. Therefore, this paper introduces blended teaching into the course of Software Architecture for graduate students, and discusses the design and practice of blended teaching based on BOPPPS.

2 Blended Teaching Design Based on BOPPPS

2.1 Teaching Theory of BOPPPS

The teaching theory of BOPPPS is student-centered, emphasizing students' all-round participation and timely and effective feedback [12]. BOPPPS divided the teaching process into six parts, which include the introduction (Bridgein), objective (Objective), pre-assessment, interactive learning, post-assessment and the summary (Summary). Each link plays its own role and is integrated to achieve effective teaching. The introduction is mainly for students to adjust the state, get ready and realize the connection of successive knowledge. The expected goals mainly refer to the learning goals that should be achieved, including cognitive goals, ability goals and ideological and political goals. The pre-class assessment is to know how well students know what they have learned, so as to adjust the depth and progress of the course content. The interactive learning is to give full play to students' main role in learning and teachers' guiding role, complete

knowledge learning, and emphasize students' participation in the learning process. The post-class assessment is mainly to understand what students have learned and assess whether they have achieved the predetermined learning goals. The summary and reflection are to analyze what we have learned through the teaching, sum up experience and lessons, and introduce the content of the next class.

2.2 Blended Teaching Model Based on BOPPPS

Through the deep integration of modern education concepts and information technology, online and offline blended teaching builds a teaching situation with high participation and strong sense of experience for students, and strives to realize knowledge imparts, ability cultivation and value shaping in talent training. The BOPPPS concept is introduced into blended teaching, and the blended teaching model based on BOPPPS is constructed as shown in Fig. 1. With the model, the teaching process is divided into three stages: the pre-class stage, class stage and the post-class one. The six stages of BOPPPS belong to different stages. In different links, teachers and students complete different activities in the teacher-led, student-dominated teaching scene on the whole. All teaching activities revolve around teaching objectives, emphasizing the integration of teachers and students, and achieving teaching objectives through collaboration between teachers and students.

1 The pre-class stage

The pre-class stage is mainly conducted online, including three parts of the introduction (B), the expected goals (O) and the pre-class assessment (P). In the introduction

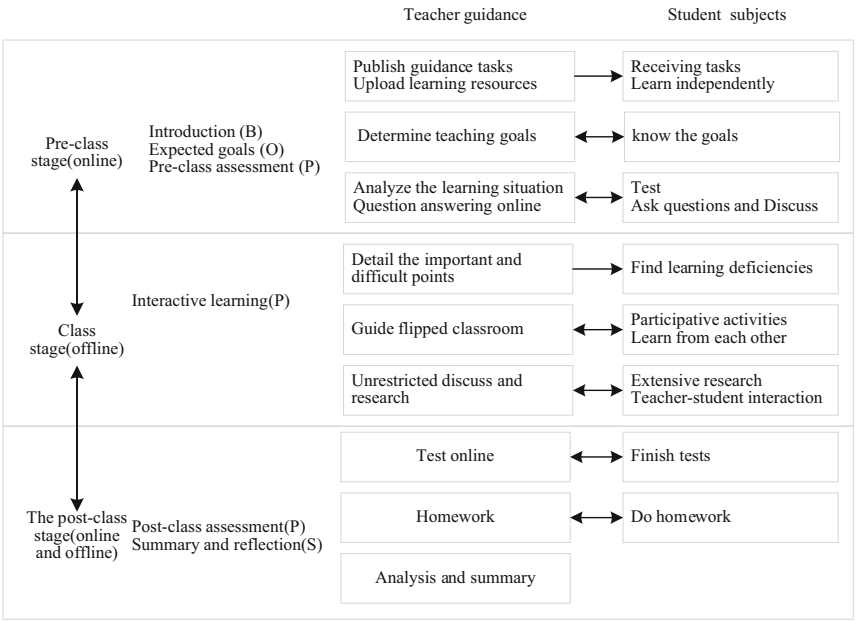

Fig. 1. Blended teaching model based on BOPPPS

link, teachers need to design the implementation plan of the pre-class stage and determine the content and tasks to be completed. According to tasks, collect and produce various resources for teaching, including MOOC resources, PPT, practice problems, etc. Considering that the graduate Software Architecture is different from the undergraduate course, teachers also need to make their own lecture videos. Teachers should introduce the new content of the course clearly, and help students understand the learning content, arouse students' thinking, arouse students' learning interest and stimulate their enthusiasm through problem-oriented, case analysis and other methods. After receiving tasks, students learn independently based on the resources released by the teacher. Students' autonomous learning is conducted in groups, and each group is required to discuss the questions raised by the teacher and determine the answers to the questions.

The expected goals mainly include the cognitive goals, ability goals and ideological and political goals of the course. These objectives should be determined around the course content as the refinement of the course objectives. Goals should be feasible, specific and quantifiable, and avoid being big or empty. Ideological and political goals are put forward under the background of ideological and political education, which is the sublimation and deepening of traditional emotional goals. As for ideological and political goals, it is necessary to identify ways or approaches to achieve them, and to have the support of corresponding curriculum resources. Ideological and political goals are achieved subtly, so we must avoid 'saturation of ideological and political'. After goals are set, whole course activities should be centered on them and should not deviate from goals. Students should know the goals before studying and can measure their online learning effectiveness by the course goals.

The pre-class assessment is mainly to analyze the learning situation. The analysis is based on students' practice completion, problem discussion and teachers' question answering. On the basis of analysis and summary of relevant data, teachers complete pre-class assessment, and carry out targeted teaching design according to the pre-class assessment results, laying a solid foundation for subsequent accurate classes.

2. The class stage

The course stage is conducted offline. This stage mainly includes the interactive learning. The interactive learning is a key link to impart knowledge, cultivate ability and practice ideological and political thinking in the course. On the one hand, it is necessary to combine the pre-class assessment results, adopt teaching, demonstration, case analysis and other methods to explain the knowledge contents that students have not mastered, help students solve the problems they encounter before class, and consolidate the implementation of cognitive goals. On the other hand, the flipped classroom, open question inquiry and other methods are used to guide students to actively participate in class, so as to change the traditional 'cramming' teaching and make students truly become the protagonists of class. In order to ensure the smooth and effective progress of this stage, teachers can adopt certain incentive mechanisms, such as giving extra points to students who actively participate in the discussion and state their own views, and taking this score as a part of the final score. In addition, teachers in this link must pay

attention to the curriculum ideological and political practice to ensure the achievement of ideological and political goals. It should be noted that in interactive learning, classroom questions and designated speeches can be used. It is also important to pay special attention to students who did not have pre-class assessment or had poor results and help these students systematically learn the content of the lesson and better consolidate the teaching content.

3. The post-class stage

The post-class stage is mainly online. This stage includes two steps of the post-class assessment and the summary and reflection. Considering that Software Architecture has the characteristics of more content and less class time, the post-class evaluation is carried out online. The main method is test online and assignment questions by teachers. Students submit online when completed. Teachers check the student learning effect through the statistical data online and obtain feedback for answering questions or adjusting the subsequent teaching implementation. Summary and reflection mainly include two levels of meaning. First, teachers summarized the knowledge points of the lecture, especially emphasizing the difficult points and key points, so as to strengthen students' grasp of knowledge. Second, teachers summarize the achievement of teaching objectives, summarize the experience and shortcomings, so as to achieve the continuous improvement and optimization.

3 Blended Teaching Practice of Software Architecture

The Attribute Driven Design (ADD) is an approach to design an architecture by taking a set of key quality attribute requirements as inputs. In this approach, the architect takes advantages of the understanding of the relationship between key quality attribute requirements and architecture design and implementation. This section takes 'architecture design based on key quality attribute requirements' as an example to illustrate the application of the bleanded teaching model based on BOPPPS in Software Architecture.

1. The pre-class stage

At this stage, the cognitive goals of this lesson are determined as to understand key factors affecting architecture design, understand the basic steps of architecture design based on ADD, and master the architecture design method based on ADD. The capability goals are to be able to analyze realistic requirements, determine key quality attributes, and design an architecture that can meet the requirements, that is, to have the ability to discover, analyze, and solve complex engineering problems. The ideological and political goals are to be able to comprehensively weigh the interests of all parties and have professional ethics. According to the course goals and syllabus, teachers make courseware and lecture videos. Instruction tasks are clearly given in courseware. There are three teaching videos, covering the knowledge points of the key factors affecting architecture design, the design steps driven by key quality attributes and ADD design examples. In order to attract students' interest, documents and videos related to software quality accidents should be collected and uploaded to the teaching platform.

The ADD instance basic demand of 'Communication Business System for Coal Mine Safety Production' [13] are described. The demand can be described as obtaining

the relevant gas concentration in coal mine by sensor items, and implementing alarms. Alarms include methods of the SMS alarm, telephone alarm and other alarms. At present, there is a safety monitoring system, and the communication service system needs to be connected to the existing safety monitoring system. The performance requires that when the average concentration reaches the threshold, the alarm would be issued within 3 s, and the safety supervision system would be informed within 2 s. At the same time, three questions should be put forward such as 'how to determine the key quality attribute', 'how to guarantee the key quality attribute' and 'how to balance the compromise'. Students should be required to study independently with questions to design the system architecture. At this stage, single choice, multiple choice and judgment questions are also set in the teaching platform to help students clarify relevant knowledge. Teachers discuss and answer questions according to the exercise and study area, and then analyze the learning situation.

2. The class stage

According to the analysis of study situation, teachers should explain the key content of the key quality attribute driven design steps in detail, and explain clearly that what specific tasks should be completed in each step and how to complete these tasks. Then, for the ADD example of 'Communication Business System for Coal Mine Safety Production', the flipped classroom is led by teachers to combine the problem discussion. This stage focuses on solving the three problems left before class. In problem discussion, attention should be paid to the cultivation of students' ability to discover, analyze and solve complex engineering problems, as well as the guidance to abide by professional ethics. The instance is explained in the following.

The flipped classroom is applied to find out 1–2 groups of students to explain the functional requirements analysis results of the communication business system. Organize student discussions. The teachers and students jointly analyze and determine that the system should have the ability to acquire sensor data, send data to external systems, store sensor data, dynamically determine whether alarms and data analysis should be performed, etc. The system use cases are given.

According to the function and the function correlation each other, the overall architecture diagram is given. Students are guided to think about how to decompose the system and determine how to decompose the system into the sensor adaptation, data mining, alarm and the communication modules.

Through discussion, the architectural drivers are selected from a specific set of quality scenarios and functional requirements. It is analyzed that the system has certain requirements for performance, availability and modifiability. Typical quality attribute scenarios are presented for the performance, availability, and modifiability. With further thought for students, the identify performance and usability are built as the main drivers of architecture design finally.

Based on the quality enhancement strategy, students are led to think about how to balance the trade-offs and ultimately choose the appropriate performance and usability tactics to establish an overall architectural pattern that satisfies the system.

Based on the teacher's explanation mainly, the system is divided into the user interfaces, usability related computing module, general computing module, performance related computing or algorithms, and the module of the communication performance according to the system's requirements for quality attributes. The basis for the division was stated clearly. With the overall architecture diagram, students are instructed to think about how to assign related functions to the architecture partitioning diagrams to achieve the module cases.

Students discuss in groups and answer questions about whether there are problems with the architecture design and what can be improved. After that, teachers verifies the scene and gives the concurrent view and deployment view. Teachers also need to compare the discussion results with students to find the omissions in the current system structure and the places which could be optimized, and complete the architecture design of 'Communication Business System for Coal Mine Safety Production'.

3. The post-class stage

The relevant test questions for this stage will be published on the teaching platform to understand the students' mastery of the knowledge. As the homework, students are required to complete an architecture design of the garage door switch in groups, and their grades are given by means of online student-student evaluation and teacher evaluation. The experience and shortcomings of this lesson are summarized. The question of how do you know if the architecture chosen for a software system is appropriate? How do you ensure that a successful software product can be developed smoothly according to the architecture you choose? And then the content of the software architecture evaluation in the next lecture was provided.

4 Conclusion

BOPPPS divides teaching into six parts to complete student-centered interactive and participatory teaching. Supported by the teaching platform, the blended teaching practices the theory of student-centered. They all emphasize student-centered, and the teaching platform provides BOPPPS with the required teaching tools. BOPPPS are introduced and based on BOPPPS, the blended teaching of Software Architecture is carried out, the teaching content is reconstructed, and the integrated teaching method of the pre-class stage, class stage and the post-class stage is designed. Students' interest in learning is cultivated effectively. These would realize the purpose of imparts knowledge, cultivates ability and practices ideology and politics finally. Curriculum teaching reform is a continuous process. The next step will be to explore more scientific indicators and methods for pre-class and post-class assessment, and then to provide better support for the improvement of teaching quality.

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