A Teaching Mode of PBL for Software Engineering Course Based on Integration of Industry and Education

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Abstract. Problem-Based Learning (PBL) is a teaching mode which is suitable for key courses of software engineering major in universities. Based on the concept of PBL, this study takes engineering of Anhui Sanlian University as an example, and is committed to building a feasible PBL teaching mode of software engineering course. Furthermore, further work is put forward to promote the development of the PBL teaching mode for local teaching environment.

1. Introduction
Teaching process of software engineering course has always been difficult for construction of software engineering major. Traditional teaching method of software engineering course emphasizes the knowledge teaching but ignores ability training. It is difficult to cultivate high-quality and complex new engineering talents with strong innovation, practical ability and sustainable competitiveness. This course is practical and comprehensive, students are not only required to master the relevant theories and methods of software engineering, but also are required to be able to apply the theoretical knowledge to the actual development of software [1]. Moreover, most of students lack concept in engineering, and even teachers themselves lack project practical experience. Many students attach great importance on the training of "programming ability", more and more time is spent on language programming courses, and the learning effect of these courses is easier to show [2].

In recently years, many teachers explore and practice new teaching methods of software engineering course actively to improve the teaching effect, such as case-driven, project teaching, blended learning based on MOOC(Massive Open Online Course)/SPOC(Small Private Online Course), flipping classroom, integration of industry and education, etc., students' interest and learning effect can be improved for a certain extent. These methods of reform are helpful and beneficial, but teachers need to establish of "students' learning ability, problem analysis and problem solving ability" as the core of teaching [2]. Otherwise, the methods above will be restricted. Universities have advantages in the teaching of theoretical courses, while advantages of enterprises are advanced technologies, project development and management, social demand docking, and so on, especially for new engineering majors, such as software engineering major. According to the mismatch between the cultivation of talents in universities and the needs of enterprises currently, universities are exploring new modes for talent training actively in order to cultivate compound talents for new engineering. Collaboration of school and enterprise, cooperation with school and enterprise to realize the talent training process, teachers explore new engineering education and its talent training paradigm for new engineering
majors, and cultivate application-oriented talents with strong engineering practice ability which are adapted to requirements of modern enterprises [3].

This paper devotes to the construction of a teaching mode of PBL (Problem-Based Learning) under background of the integration of industry and education. The structure of the paper is organized as the following: Section 2 defines the concept of PBL. Section 3 explains how to design the teaching mode of PBL based on integration of industry and education. Section 4 is developed to the construction of a feasible teaching mode of PBL for the course of software engineering as a study case of Anhui Sanlian University. Section 5 concludes the paper and puts forward the further work.

2. Concept of PBL

PBL (Problem-Based Learning) is an inquiry based learning teaching mode that scientific knowledge is hidden in the problem by solving practical problems, traditional and passive teaching method is turned into the method of active and autonomous learning. It is centred on students instead of teachers that help to cultivate students' self-learning ability, positive thinking ability, practical problem solving ability and innovation ability [4]. PBL helps students to simulate decisions in classroom through real, complex questions or cases. The problem is the core that carrying the entire learning process of PBL. The problem is taken as the driven who conducts students to further explore on the required knowledge, and the process of solving the problem is also the process of self-directed learning and internalization of knowledge [5].

With the continuous development of education reform, the cultivation of innovative talents has become a key goal of higher education of China. A variety of teaching methods such as inquiry, coordination, discovery, interaction and so on are widely used in the students' learning process to stimulate students' innovative consciousness and cultivate students' thinking ability. Teaching mode of PBL has been widely used in higher education in foreign universities. On one hand, actual problems can be resonated with students which enable students to use existing knowledge with their own experience to reconstruct and expand new knowledge [5]. On the other hand, when students are thinking about these real problems, the knowledge can be truly realized and applied on the similar teaching environment and working scenarios.

3. Teaching mode of PBL based on integration of industry and education

Persisting in conduction of talent requirements, the concept of integration of industry and education is carried on for new engineering is the key factor in new era. The participation of enterprises and industry experts in the curriculum system design and practical teaching plays an important role in major construction, and the establishment of a "double-win" cooperation mode in which enterprises and universities with each other and share resources is the basic guarantee for the continued in-depth cooperation between universities and enterprises [6].

3.1. Approach of integration of industry and education

During the teaching in classroom, integration of industry and education highly emphasizes the teaching modes of case driven of enterprise, seminar teaching, inquiry teaching, project grouping teaching, etc. University teachers are encouraged to incorporate the latest technological achievements of industries and enterprises into the curriculum system as learning cases, and the proportion of comprehensive, innovative, and engineering learning cases are increased.

Students' interest and initiative in learning can be increased by teaching mode of PBL, students' participation in teaching process can be improved, and positive learning achievements can be obtained. PBL is more suitable for advanced learning of software engineering major, such as courses of software engineering, software testing [2], which is a positive teaching mode of integration of industry and education.
3.2. Process of PBL mode
Actual problems in real scenarios must be the starting point for learning in PBL mode, teachers organize the learning content by proposing the problems, and take students as the key part for exploring on the solutions of the problems. Process of PBL mode which is designed is shown as Figure 1.

Teachers complete designing of a series of problems carefully from the perspective of enterprise application for the knowledge domain of the course before the class, and put forward the problems which are need to be discussed in class. Students communicate with each other in groups to complete the discussion and analysis of the problems. Teachers do not participate in the discussion of students, but they must always pay attention to the discussion of students. They need to be corrected in time to deviate from the subject and incorrectly understand the problems, and give a unified supplementary explanation of common problems [2].

Students seek solutions through on-site accessing to books, online website, etc. according to exceeding discussion and finish writing reports. Finally, teachers and enterprise engineers comment on the results together, including an overall evaluation of each group and a self-evaluation of each student in the group [2].

4. A feasible teaching mode of PBL for the course of software engineering
The course of software engineering is the key course for software engineering major, which software development, software management, systems engineering, document writing, mathematics, etc. are involved in multiple areas. It has strong comprehensiveness, and it is closely contacted with IT project operation process in the software enterprise. Students' learning cognitive ability is not only limited on "remember", but also requires "analysis, application, evaluation and creation". Moreover, from the perspective of enterprise applications, the knowledge of modern software engineering is rapid updated, continuous learning must be in process by network resources for teachers and students.

It is obviously that construction of a teaching mode of PBL is necessary. In this section, a feasible teaching mode of PBL is developed and applied as a study case of software engineering course for the software engineering major of Anhui Sanlian University.

4.1. Design of problems from software enterprise
Problems should be designed systematic. Not only the whole knowledge of the course is covered, but also the knowledge that derived from software enterprise applications is included. Application of new technologies in software engineering area is updated rapidly, teachers and engineers of software enterprise should review and update the problems every year. Some problems of purely theoretical or
outdated should be abandoned. Problems of software engineering course that designed by teachers and engineers together are shown as Table 1.

Table 1. Problems of software engineering course.

| Problem                        | Keywords for Knowledge Area of Software Enterprise                                                                                                                                 |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Goal of Software Engineering   | product quality; optimum practice; low cost; less quantity but more quality on staff                                                                                                     |
| Agile Development              | individuals and interactions over processes and tools; working software over comprehensive documentation; customer collaboration over contract negotiation; responding to change over following a plan |
| Requirement Analysis           | requirement acquisition; method; process; tool; prototype                                                                                                                              |
| Software Function Requirement  | business requirement; user requirement; product requirement; quality attribute; SRS                                                                                                      |
| Software Module Structure      | design style; coupling and cohesion; architecture system                                                                                                                               |
| Human-Computer Interaction     | GUI; human factors and ergonomics; user experience; VR; comfort degree                                                                                                                 |
| Design                         | program annotation writing; data declaration; program statement writing; design style of input and output                                                                            |
| Coding Standard                | definition; faction; method; layer; mode; technology; process; management                                                                                                               |
| Software Testing               | listening to appeals; participate in QA; transfer to the cloud; continuous regression testing; install new software versions by standardized procedures                                       |
| Software Maintenance           |                                                                                                                                                                                         |
| Object-Oriented                | OOA; OOD; OOP; OOT; UML                                                                                                                                                                  |
| ......                          | ......                                                                                                                                                    |

4.2. Questions and discussion

Students are guided to think and discuss problems which are designed by teachers should be from the perspective of enterprise applications. It is noted that the guidance area for students to think about the problems must be related to the actual business of enterprise, and if necessary, it can be supplemented by an enterprise case for demonstration.

Discussion could be organized and implemented in groups. "Brain Storm" is encouraged for students to collect various factors which are affected with a problem [2]. Table 2 is a template for questions of the problem of "Software Function Requirement", discussion from the view of software enterprise for each student group should be recorded.

Table 2. A template for questions of the problem of "Software Function Requirement".

| Problem                        | Questions [2] | Discussion from the View of Software Enterprise |
|--------------------------------|---------------|-----------------------------------------------|
| Software Function Requirement  | What to do of this function? |                                                                 |
|                                | Who want to do of this function? |                                                                 |
|                                | Which business requirement of software will be relied on this function? |                                                                 |
When will it be misused of this function?
This function will be a part of another function of the software?
What can be improved of this function?

4.3. Analysis and solution
Students are encouraged to analyze the problem through multiple channels, such as books, Baidu, online forums, MOOCs, and so on. For some complex problems, actual investigation on local enterprises can be allowed for students to seek corresponding solutions.

4.4. Evaluation
After each group completes the discussion, teacher needs to make serious comments on the group as a whole and each member of this group. Mutual evaluations between different groups are encouraged, but the imperfections and improvement should be focused on for each student group.

5. Conclusions and further work
This teaching mode of PBL for the course of software engineering of Anhui Sanlian University was implemented in year of 2019 and experimental effects were positive. The first and foremost, the rate of student attendance in class is increased to 80 percent. There is one more point, students have a more grasp of technologies of software engineering and received positive comments from local software enterprises.

From my own perspective, further work of PBL will be done in the future. Firstly, exploration on the most suitable form of PBL teaching mode that is integrated with local teaching environment. Questions and discussion for PBL are implemented in a local classroom on campus or through the website of Internet, which will be further researched. Secondly, from the perspective of applications of software enterprises, appropriate evaluation and scoring standard for questions and discussion of students groups should be designed. Enterprise engineers need to participate in stage of evaluation and scoring deeply. Each item on scoring standard is needed to be refined and quantified, which is based on the software enterprises. Third, PBL teaching method requires students' active cooperation to achieve positive results [4]. Enterprise engineers need to create certain incentives so that most students can actively participate in PBL, and the incentives must be diverse and feasible.

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