The Discussion of the Problem-Based Learning in Small Private Online Course of Mathematics in University

Xinghu Teng[1*], Xiao Han[1], Yongting Zhu[2], Lei Mao[1], Yu Pei[1]

[1] Department of General Education, Army Engineering University of Pla, Nanjing, 210000, China

[2] National University of Defense Technology, University of International Relations, Nanjing, 210000, China

*Corresponding Author

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Abstract: The traditional teaching mode is no longer adapted to the cultivation of innovative talents. In all kinds of new teaching modes, the “problem-based learning” teaching mode is a useful exploration. By designing the appropriate questions in the classroom teaching or online teaching platform, it can give full play to the role of “learning as the main body and the teacher as the leading role”, and can effectively increase the participation of students in the teaching process, and cultivate innovative ability of students.

1. Introduction

The traditional teaching model in the classroom, to some extent, is no longer meets the needs of the current society for education. It is not conducive to the promotion of students' enthusiasm, initiative and enthusiasm for learning, and is not conducive to promoting the cultivation of innovative talents. In the teaching practice, it is necessary to reform the classroom teaching mode. Among all kinds of teaching modes, the problem-based teaching is a beneficial exploration. In fact, the problem-based learning (PBL) was a pedagogical experiment at McMaster University in the late 1960s, and it has been shown the idea that problem-based learning (PBL) is more motivating that traditional education has been prevalent [1]. What is most remarkable about it is the extent to which it shaped medical education research, and then spilled into all areas of higher education [2]. Also, the key discussion and debates about pedagogy and education research were raised in and beyond the health sciences education sphere [2] In many domains, the principles of PBL have also been worldwide recognized. And based on local educational beliefs, the PBL models and learning strategies are adopted in higher education Settings [3]. The higher education based on the principles of PBL has developed in response to changing educational and societal conditions Since PBL first implementation. In higher education,the practices and approaches arising from the principles of PBL are highly diverse [4]. For the different of the field of study or the prospects for students beyond their university education, there may be significant differences in the way PBL is practiced in different course, different institution or even within the same institution [3]. For example, the PBL models and learning strategies practiced in a math course may be different from the way practiced in medicine course.

On the other hand, in recent years, different from traditional teaching methods, there are some emerging form of online learning practiced widely based on network and mobile intelligence technology such as Massive Open Online Course (MOOC), Small Private Online Course (SPOC), iCourse, etc. Among there form, for SPOC often has a certain restriction on the number of attendants, it is more suitable for courses provided by colleges to their students. SPOC is consists of two parts: group-based interactive learning in class, and computer-based individualized learning after class [6]. Where the online teaching often includes pre-learning and the expansion and feedback in after-class. It integrate the online teaching and offline classroom teaching, and this integration breaks through the fixed, closed and one-way traditional teaching mode centered on teachers, and truely realizes the student-centered individualized learning in practiced[5]. In this

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article, we discuss the integration of PBL and SPOC in mathematics courses.

The rest of this paper is organized as follows. Sec. 2 focused on design issues: how to design the problem based on the Basic knowledge of mathematical theory. Then it presents where to introduce the problems in different stages in SPOC and the role of the problems in Sec. 3, Based on the guidance of problems, students can have a deeper understanding of theoretical knowledge through pre- learning before class, learning and discussion in class, and application and expansion of knowledge after class. In Sec. 4,We discuss the teachers' responses to the feedback of student at different stages of SPOC. Finally, it ends up with the conclusion in Sec. 5.

2. Design Problems for Pbl and Prepare for Spoc

The core of PBL is problem design, and appropriate problem design is the foundation of SPOC teaching activities.

2.1 Designing Problems Based on Students' Cognitive Level

The problems designed in PBL should be “adapted to students' cognitive level “. The same problem may not apply to different teaching objects. Effective problem, should be able to make students get it if they make efforts, and can enable students to make the best use of the knowledge they have acquired and develop their ability to expand, can focus students' attention and promote their interest in learning. This requires teachers to avoid inaccurate positioning of problems designed for teaching objects. The teacher should know the knowledge the students have mastered and their cognitive level, and then design specific problems. For example, mathematics course, we can design a problem like this: variables are everywhere in nature, so what are the relationships between variables? Only by using appropriate problems to carry out and organize teaching can we make teaching easy and efficient and improve teaching efficiency.

2.2 Designing Problems Based on Knowledge in Textbooks

The basis of teaching is usually based on the textbook. In textbooks, the given teaching knowledge are often concise, mature and rigorous statements. If teaching activities are carried out directly according to the textbooks, they are usually straightforward, placid. This also easily leads to rote learning, the teaching process is often dull. In the actual teaching process, the corresponding problems should be designed according to the content of courses to reflect the occurrence, development, perfection and application of knowledge. By creating problem situations and the problem designed through the whole teaching process, students' interest and instinct for knowledge can be stimulated. For example, the limit $\lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n$ and the proof of it is given directly usually in advanced mathematics textbooks. This ignores the meaning of this important limit. So for the limit $\lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n$, we can design a series of problem, such as what the meaning of the limit is, and what kind of generalization of the limit, and why this limit is important and so on. If the connotations problems designed based on and rich than the knowledge in textbook, it can help to interpret the textbook theorem, conclusion or example to the greatest extent, and can help students to understand the context of knowledge. This is helpful to promote students' cognition of knowledge point formation.

2.3 Designing Problems from Real Life

Theory comes from the reality of life. In the process of learning, one can return to the original simplicity and find the source of problems in life. For example, by discussing the number of goods sold and the average number sold, it can deepen students' understanding of the concept of Poisson distribution and the mathematical expectation of Poisson distribution. Some knowledge is often hidden in the phenomena and problems in life. Teachers should make students become the main body of teaching activities, guide students to observe and sort out relevant materials in life, to

compare and analyze relevant theories with textbooks, to integrate and conclude knowledge through association, communication and discussion in the end, and then students can complete the study of knowledge. As the subject of learning, students can grasp the essence of the mathematical theory more profoundly if they learn it from the mathematical problems in life and the root of the theory of science and mathematics, and reproduce the generation, development, perfection and application of the mathematical theory.

3. Choosing Teaching Situation Based on the Application of Problems in Spoc

Only in the corresponding and appropriate teaching situation, different problems can play the role of the problem.

3.1 Applying the Problems to Pre-Learning and "Worm-Up" the Classroom Teaching of Spoc

Limited by the ability and insight of students, the problems posted in pre-learning of SPOC before class should not be broad and too difficult. Problems should be connected with classroom teaching so as to facilitate the development of classroom teaching. For some simple problems that pave the way for classroom teaching, online teaching network platform or other ways can be used to release the problems before class. For this kind of problems, students can solve it by reviewing the anterior knowledge, prerequisite of classroom teaching and simple thinking and discussion. Or after these activities the problem can't be completely correct to solve. On the one hand, if the problem can be successfully solved, it can positively motivate students to study. On the other hand, if the problem cannot be completely solved correctly, students should think about the topic of this class with the problem in mind, which is conducive to improving the efficiency and effect of classroom teaching. For example, in the discussion of quadratic forms in a linear algebra course, the problem can be set for pre-learning: If the quadratic form is made up of the sum of three squares, is it positive definite? This problem is conducive to cultivating students' divergent thinking and facilitating the connection between pre-class teaching and classroom teaching.

3.2 Carrying out Flipped Classroom or Discussion by Applying Questions to Classroom Teaching

Classroom teaching is an important stage of PBL mode. Problems used in classroom teaching can be trap problems. Students fall into traps and cannot solve them. At this point, the effect is often better than that of directly informing the conclusion. Problems used in classroom teaching can also be the discrimination of problems, the answer of the problem is not clear, students may understand the reason why the answer to the problem are unclear or have multiple answers. For example, for a quadratic form consisting of a sum of three squares, the student may assume that the quadratic form is positive definite as he finds the quadratic form is the sum of squares. In fact, the quadratic form can be positive definite or semi-positive definite. This needs to be determined according to its specific form. For the development of the flipped classroom combining problems, on the one hand, students can be guided to participate in the discussion of problems according to the teaching design, step by step, and finally solve the problems to achieve the teaching purpose. On the other hand, in the process of active participation of students, new problems will constantly emerge. The emergence of these problems requires teachers to timely insight into the information, understand why students have these problems, and think about how to solve these problems. A careful analysis of the problem can prevent students from going astray, and can make students understand the "theory" of knowledge deeply.

3.3 Applying the Problems to the Extension of after-Class in Spoc

Problems to the extension of after-class generally include several types. One is the consolidation of knowledge in this class. By thinking and discussing of this kind of problem, students' mastery of knowledge in classroom teaching can be promoted. For example, after the teaching of indefinite integral, one may give the student the problem that whether two functions are equal if their derivatives are equal. And this problem can consolidate students' understanding of the concept of

antiderivative central function. The second kind of questions is to pave the way for the next class, which plays a role of connecting the preceding and the following, and helps students to form the context of knowledge clearly. For example, if two shooters shoot the same number of target rings, how to judge their shooting level. This problem is the application and consolidation of mathematical expectation, and also the teaching of variance. The third kind of problem is a kind of problem of knowledge application. For example, how the U.S. nuclear submarine scorpion was found after it was wrecked and sunk. Bayes' formula is used to solve this problem. Through the exploration of this problem, students can better understand and apply this formula. Designing appropriate and hierarchical knowledge application problem can make students become the center of problem based teaching. The application of this kind of problem can cultivate students' independent thinking ability, inquire information and literature, and cultivate students' ability to find, analyze and solve problems. This is the ultimate goal of teaching.

4. Forming Closed Loop of Teaching Process by the Teaching Feedback of the Problem

The end of classroom teaching is not the end of teaching activities, but only a main part of teaching activities. A complete PBL process must have a process of problem feedback, so as to form a closed loop of teaching activities.

4.1 Focusing on Instant Feedback in Interaction between Teachers and Students in Teaching

The teacher should change the tradition teaching method ”the full house fills”, and needs to pay attention to the interaction between teacher and students. In the process of teacher-student interaction with “student-centred” and “teacher-guided”, the contradiction and unity between teaching and learning can be fully demonstrated. It is necessary to pay attention to students' direct feedback and indirect feedback when raising, developing and discussing problems in class. Direct feedback often takes the form of verbal communication. Indirect feedback is often presented in students' microexpressions. Only when teachers make appropriate decisions on how to carry out teaching activities based on these feedbacks can the teaching effect of a class be maximized.

4.2 Focusing on the Feedback of Student on the Spoc Platform

After class, the process of students' Digesting, absorbing and consolidate knowledge, which is a continuation of classroom teaching. For this part of the learning links outside the classroom, teachers need to follow up in time. SPOC is an appropriate platform for this. Using the functions of SPOC platform such as the teaching forum, answering questions and other related functions, can help students to raise questions timely, and help teachers solve the problem in time. On the other hand, due to the openness of the online network platform, it is convenient for each student to understand the problem and track the progress of problem solving. The application of the function column of the network platform is a beneficial extension and supplement of the classroom teaching activities.

4.3 Focusing on the Face-to-Face Feedback of Students Based on after-Class Counseling

For all the questions that were raised in class and all the questions that came out of it, due to the limited functions of the platform, it is inconvenient for students to display graphs, tables or formulas on the platform. But if conducting face-to-face dialogue, these will be more convenient to give, and it is also convenient for teachers to solve puzzles by means of graphs and tables. On the other hand, for some students, they may not be able to fully digest knowledge in class, but they may not be able to form a complete language to describe what their doubts are. However, in the process of answering questions in the language communication, teachers can properly capture the information and answer their doubts.

5. Conclusion

In the teaching process of SPOC, combining with the teaching mode of “problem-based

learning", this is a beneficial exploration of teaching mode. In the different stages of SPOC teaching, proper design problems correspondly, combining with the application of problems and the feedback of problems, which can give full play to "student-centred" and "teacher-guided", and can effectively improve students' participation of teaching process, to cultivate the students' innovation ability, and Maximize the effectiveness of teaching.

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