

Research on the application of flipped classroom in Engineering Experiment Teaching

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Abstract: Flipped classroom teaching mode is the inversion of the traditional classroom. It is a teaching mode that puts learning knowledge before class and understanding knowledge on class. The teaching mode of flipped classroom is adopted to reform the teaching content and teaching mode of engineering experiment. The effect of experimental teaching is improved. Taking MOOC as the carrier, a new experimental teaching mode based on flipped classroom is constructed by means of setting questions before class, watching MOOC and other materials, exchanging and discussing, discussing and answering questions in class, and completing experimental reports after class. The students' interest in autonomous learning is stimulate effectively. The ability of students to find, analyze and solve problems are improved.

1. Introduction

With the education entering the information age, how to rely on information technology to change the traditional form of education and promote the teaching quality of engineering is an important issue. It determines the cultivation of engineering ability of college students. Flipped classroom teaching mode is completely different from the traditional teaching mode in and out of class. It is to impart knowledge before class and internalize knowledge in class. Compared with the traditional teaching mode, it is reversed.

Jon Bergmann and Aaron SAMs of the United States first proposed flipped classroom as an independent concept [1]. With the introduction of this teaching mode into China, more and more Chinese researchers have carried out applied research on this [2-4], Ma Xiulin and others applied the flipped classroom to university information technology courses, and through comparative analysis, it is found that the flipped classroom has a promoting role in the cultivation of ability [5]. Jiumin Yang and others have introduced the flipped classroom teaching mode in view of the practical problems existing in the experimental teaching. It had a good effect on students' autonomous learning and knowledge understanding [6]. Ding Xuemei and others designed the corresponding flipped classroom teaching mode, based on the experience of experimental teaching. They analyzed some focus problems in detail, and made a reference conclusion [7]. Domestic research results show that the flipped classroom teaching mode has obvious advantages in cultivating autonomous learning, team cooperation, communication and expression, etc. Flipped classroom teaching mode can greatly stimulate the enthusiasm and initiative of students, change the traditional teaching concept, and have significant effect in training innovative engineering talents.

2. Theoretical basis of flipped classroom

2.1 Mastering learning theory

The core idea of this theory is that under the premise of ensuring sufficient learning time and reasonable teaching, all students can master the corresponding knowledge and content. Different

students may have different speed in mastering knowledge, but if they have all kinds of learning conditions, almost all learners can master the corresponding content. Mastering learning theory is an important theoretical basis of flipped classroom teaching mode. In the process of classroom flipping, we can take full advantage of diagnostic evaluation, formative evaluation and summative price to carry out teaching activities, provide students with readily available teaching resources, and guarantee their learning environment and conditions. Especially for students who are slow in mastering knowledge, they can watch the corresponding videos, PPT and other learning materials repeatedly at any time, so as to master the corresponding learning content.

2.2 Constructivism learning theory

The constructivism learning theory originated from Kant's philosophy. It combined rationalism and empiricism, and constructed the thought of individual subjectivity from the perspectives of cognition and practice. The four elements of constructivism learning theory are "situation", "cooperation", "conversation" and "meaning construction". In the process of classroom flipping, constructivism theory focused on students, teaching in the actual situation, discussion and cooperative learning between teachers and students, providing sufficient resources such as information conditions and learning materials. Based on the theory of constructivism, the flipped classroom advocated the process of students' active construction rather than the process of "indoctrination". The flipped classroom emphasized the main role of students in the process of knowledge transfer and internalization, and advocated the construction of an independent and open learning environment.

2.3 Blended learning theory

The core idea of this theory was to reduce the cost and improve the teaching quality as much as possible by integrating online learning and face-to-face teaching mode. This blended learning theory usually integrated online learning resources and traditional teaching resources, and created online learning and traditional teaching environment. Before class, students choosed their interested teaching videos on the internet according to their personal needs, learned knowledge through online learning. In class, if students encounter problems that was difficult to understand, they could solve the problems through mutual assistance between teachers and students. In this way, they could really understand knowledge and complete the internalization process. Therefore, flipped classroom was an effective combination of traditional face-to-face teaching and online learning. The flipped classroom created a new teaching mode using micro video and related technologies. It not only embodied the leading role of teachers in instruction, inspiration and management, but also fully embodied the creativity and initiative of students. So as to achieve the best teaching and learning effect.

3. Characteristics and current situation of Engineering Experiment Teaching

Generally in the engineering courses, the proportion of experimental teaching was very large. Taking the course of drilling equipment as an example, this course mainly studied the structure, principle, working characteristics and other knowledge of common auxiliary parts such as drilling rig, power machine, mud pump, etc. The basic theory of mechanical design, hydraulic transmission, drilling technology and other courses were needed before this course. Most engineering courses required students to have a strong ability of three-dimensional space imagination and practice. Train students to be able to use the knowledge they have learned and analyze the principle, performance and characteristics of complex structures. This courses developed the ability of students to use the learned knowledge to analyze the principle, performance and characteristics of complex structures.

Many engineering courses needed a large number of experimental teaching to help students understand the course content. Through the actual operation, students could understand the structure and working principle of each component, acquire the operation steps in the actual production work. The foundation for students in the production work and scientific research were laid in the future.

The following problems were existed in the traditional experimental teaching process of the drilling equipment course:

1. The disassembly of experimental equipment was difficult.

The equipment used in the experiment teaching covered a large area and had a large height. The whole weight of the drill is more than 1 ton, so it is difficult to move. The weight of a single part was more than 100kg, so the disassembly work needs many people. At the same time, the internal structure of the components were complex, such as the friction clutch is composed of 27 different parts, and most of the parts required matching accuracy. It was difficult to the students' actual disassembly and assembly operations.

2. The operation required the cooperation of many people.

In the course of experiment teaching, many operators required the cooperation of many people. For example, for the operation of screwing out the drill pipe, because the two drill pipes were closely connected, at least two people were required and mutual cooperation was needed.

3. There were safety risks.

The experimental equipment had high turning speed and high working pressure, which had a potential safety hazards. Moreover, when students operated for the first time, they were unskilled operation and lack of experience in dealing with emergency events. In large classes, teachers couldn't pay attention to every student, so safety accidents were easy to occur.

All of the above mentioned, the traditional experimental teaching method was difficult for each student to grasp the experimental teaching content within the specified time. The traditional experimental teaching method could not meet the requirements of experimental teaching.

4. The advantages of flipped classroom

4.1 The development of MOOC provides strong support for the application of flipped classroom

MOOC was originated from the "open courseware project" by MIT in 2001. After nearly 20 years continuous development, many well-known Chinese universities have also established and joined the MOOC platform. The online learning platform also created a good condition for the communication between teachers and students in their spare time. With the continuous development of online courses, online education in schools had become the focus of attention.

In the experimental teaching of drilling equipment course, the whole weight of the drilling rig was more than 1 ton and most of its parts were also very large, so it was difficult to demonstrate and dismantle in practice. The operation of the equipment needs many people to cooperate, so one person couldn't complete the operation independently. Thus it was difficult to implement the traditional experimental teaching method. In classroom teaching, students received too much information to remember and understand it effectively. Students just imitate the operation step by step, and forget as they do. The incomprehensible problems were also difficult to make a profound study in class. At the same time, students operated unfamiliarly, so there were certain safety risks. Based on the above problems, a complete MOOC system for drilling equipment had been built through the network teaching platform such as superstar. The 105 knowledge points are summed up in the drilling equipment course. The teaching and experiment videos were made according to the chapters. Students could study online at anytime and anywhere. There are 200 homework questions, 15 test questions and 10 interactive questions on the teaching platform. In order to improve the students' ability of reading pictures and three-dimensional imagination, a three-dimensional animation of 18 components such as friction clutch, gearbox, elevator and rotator were developed, based on 3DSMAX and unity3D computer software.

Therefore, the existing online resources of MOOC could be used in the flipped classroom teaching mode. More practical discussion activities could be held in the class. The development of MOOC further promoted the development of flipped classroom and provides a better environment and support for its development.

5. Flipped classroom is conducive to autonomous learning and individualized teaching.

1. The cultivation of autonomous learning ability was cultivated. Chinese college students were used to "indoctrinate" learning. They have poor awareness of autonomous learning and discussion, which made a negative impact on the mastery of course knowledge and the cultivation of ability. College students generally had a flexible extracurricular learning time. With the support of network information technology, flipped classroom could make students set their own learning step according to their learning ability. In the flipped classroom, there were no obvious time and place restrictions on learning. Students could learn freely in some spare time, such as rest, waiting and taking bus. For students to master knowledge, pay attention to teaching students learning methods. Teachers pays more attention to teaching students learning methods in flipped classroom. In particular, the concept of building a lifelong learning society putted forward by the state. It was to pay attention to the cultivation autonomous learning ability of students. The ultimate goal of this teaching mode was not to teach knowledge, but to teach students how to ask, analyze and solve problems, so as to improve students' ability of autonomous learning.

2. Teach students according to their aptitude. Because there were great differences in teaching level in different regions, the learning ability and operational ability of students in different regions were quite different. Some students felt that the teaching content was single, and they expected the knowledge and experiment content to be more abundant, so as to speed up the knowledge updating; Some students felt that knowledge content is too much, students are too busy to attend to all in the classroom, learning is more laborious, and even some students only look at the practice and rely on others

The flipped classroom could teach students according to their aptitude and meet the learning needs for students with different knowledge levels. The principle of instruments could be displayed in three dimensions through MOOC class. The students' ability of invention could be cultivated. Students first watched the multimedia course. Their knowledge was consolidated through repeated watching, thinking and taking notes. The gap of knowledge level and experimental skills between students were narrowed. It is more important that the psychological gap between students were narrowed.

6. Experimental teaching mode based on flipped classroom

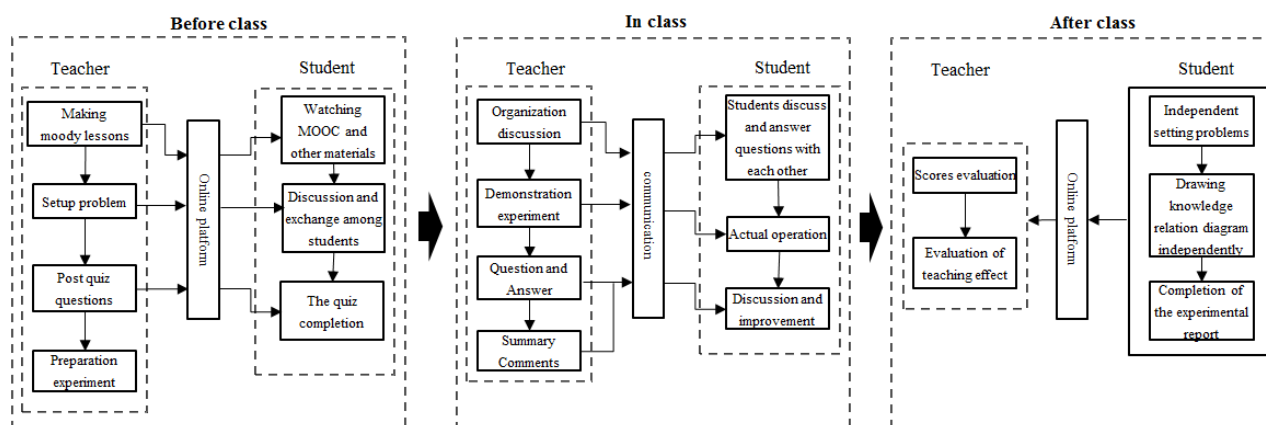


Figure 1. A diagram of the experimental teaching model of the flipped class

In this paper the flipped classroom teaching mode was introduced into experimental teaching. The traditional teacher led teaching mode was changed into the new teaching mode of "leading one main body". The flipped classroom got full play to the leading role of teachers' teaching and the main role of students' learning, mobilized the enthusiasm of both and realized interactive teaching. The specific teaching steps were as follows: watching MOOC and other following before the class was conducted; discussions and communications among the students; completing a minor test, the students discuss each other with each other in the course of the class, the actual operation, the

discussion and improvement, putting forward topics by the students themselves after the class, the knowledge relation graph which were drawn by the students themselves, and completing the experiment report. The particular mode and structure of the flipped class in the experimental teaching was as shown in Fig. 1.

6.1 Putting forward the topics before class

The top priority of the class was to put forward certain topics by the teacher according to the content of the class, and the students would conduct the discussion and exchange among them using a group as a unit and solve the problem together. As a flipped class which was based on the students, how to put forward a problem which could stimulate students' interest in learning should follow the following principles.

1. The key points of experimental teaching would be used as the guidance in the course. In the experimental teaching of the course, attention would be paid to the cultivation of the practical ability of the students. The perceptual understanding of the students will be increased through personal experience which was obtained in the practical operation and their understanding of the structure and principle would be also be deepened in this way. On the basis of the curriculum content, combined with the objectives of the curriculum teaching and taking into consideration of the learning ability of the students, the topic were carefully selected.

2. The practical engineering problems were related closely. The students would feel more attractive, which could stimulate the enthusiasm and initiative of the students for solving the problems. Taking the drilling equipment course as an example, it would possible to put forward this issue: "The function of drilling rig friction clutch". Then this topic may be set up: The engine of the rig could not stop frequently, and the motion of the rig changes frequently, how to realize this? When a drilling rig or car gearbox changed gears, it often occurred that the gear was not in place. analyze the reason and explain how to solve it? When trying to take the drill rod from the hole and grasp the core which has fallen onto the bottom of the hole, how to carry out the operation in an effective and reliable manner?

3. The degree of difficulty was moderate. Considering that this was the first time that the students contact with the relevant mechanical equipment, the cognition of drilling method is in the construction stage. As a result, some complicated operation were difficult for the students to understand. This may easily leded students to lose confidence in solving the problems. On the contrary, some problems which were too simple and easy for the students to complete. So it would be not possible for the students to experience the wonderfulness in solving different problems by combining several operation techniques. So it would not be possible to arouse the enthusiasm of the students. At the same time, we should consider the study habits and self-study ability of the college students in our country under the traditional teaching mode. Under the guidance of the teacher, through the thinking and discussions, the students were able to solve the problems by themselves. in this process, the student could achieve the greatest through solving the problems.

6.2 Watching MOOC and other data before class

Before the teaching was carried out, the students could freely watch the MOOC courses and the learning atmosphere was very good. The students could access the Internet themselves to find the knowledge to solve the problems encountered. According to the sections of the course on the drilling equipment, the teaching and experimental lesson videos were produced. With regard to the scientific and engineering courses, there were a large number of key components and parts, the structure of the equipment was complex, the internal structure of the equipment and the work process were difficult to observe. In addition, the explanations which were given in the two dimensional way were also too abstract to understand. Therefore, 3DSMAX, unity3D and other kinds of computer software are used to create 3D simulation animation of the main components. Through the network platform, it would be possible for the students to view the simulation demonstration of the structure and working principle of each component in advance. With regard to the three dimensional structural model of the transmission and the picture of the real object, the

three dimensional structure of the real object is difficult to observe in the physical object. However the internal structure can be clearly seen through the three dimensional animation. The internal working process and the meshing relationship among all the gears and the transmission route between the parts can be clearly observed. The animation effect was more suitable to the students' taste and the interests.

6.3 Exchanges before class

One of the important steps in the flipped class was the collaborative learning. Under the guidance of the collaborative learning, the learning activities of the students were not absolutely independent. In the cooperative learning atmosphere, it was possible for the students to communicate with other students or teachers through the online platform in order to solve some difficult problems. In this process, the students would have a profound understanding of the importance of learning and the sense of self existence. As a result, the students will be more interested in the exploration of new knowledge. The role of a teacher was changed. Now the role of the teacher had become the developer of the teaching resources, the leader of the knowledge as well as the organizer and the promoter. In this mode, that teacher was able to master the students' learning situation and to provide guidance to the students, the teachers should make specific guidance in the class through effective communication with the students in the early stage and the problems existing before the class.

6.4 Discussion and answer in class

In the flipped class, the step in class was also a key step. During this step, the students would be encouraged to communicate with each other, solve the problem together, and correct any errors of another student, so that all the students could have a deep understanding of the essence of the problem. The teacher would not only be the organizer of the discussion, but also would act as a participant of the discussion. With regard to any problem that the teacher may encounter during the course of the self-study of the students before the class, including the questions which the has designed prior to the class, the teach would further assign and arrange new topics which were more difficult or innovative ones. The purpose of this step was to improve the ability of the students in using the knowledge to solve problems.

6.5 Experimental operation

In the flipped class, the transferring of knowledge was carried out out of the class. This would use less teaching time in the process of experimental teaching. The time for the experimental operation and discussion of the students as well as the time of teacher guidance had been appropriately prolonged. In this way, the unity between thinking and learning as well as the unity between knowledge and practice had been realized. Instead of blindly imitating, students would carry out organized experiments on the basis of digesting and understanding knowledge, and then the knowledge would be constructed through experiments. As the result, the purpose of integration through carrying out a large number of experiments may be achieved.

6.6 Completion of the experimental report after class

The purpose of experimental report was mainly to summarize the problems and knowledge points which had been discussed. Different from the traditional classroom in which the teachers arranged the topics, in the flipped class teaching mode, the students were required to design the relevant topics and find solutions to them by themselves. The students were required to draw the knowledge relationship diagram and complete the related homework independently. The students would find solutions to these topics from the point of view of the teacher, which made them think more deeply and comprehensively about the problems. On the basis of reviewing the existing knowledge, the students would be able to acquire new knowledge, which provided students with a great space for innovation. As the result, the students would get a greater sense of achievement, and their enthusiasm and initiative to learn could be really stimulated.

7. Summary

In the teaching mode of the flipped class, the traditional “Transfer - Accept” style teaching mode, which was dominated by the teacher, had been transformed into the “Dominance - subject” teaching mode. In this teaching mode, the teacher played a leading role, and the students fully embodied their role as the learning main body. The purpose of this was to arouse the enthusiasm of both the teachers and the students to form the interactive teaching. In this paper, the experimental teaching content and the teaching mode of the engineering course were reformed by using the teaching mode of the flipped class. MOOC was used as a carrier, the classes of the scientific and engineering course and the flipped class were combined in an organic manner. As the result, the problems which existed in the experimental teaching have been solved. The interest of the students' learning had been stimulated to a great extent. The autonomous learning, practice innovation, language expression as well as team assistance had been fostered. In addition, the ability of the students to find, analyze and solve the problem had been obviously strengthened.

As a new teaching mode, there was also a great space for exploration and research for the flipped class. With regard to the issue how to play its role in the experiment teaching using its advantages while avoiding its disadvantages was still remain for further research and development.

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