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Research on the Student-centered Blended Teaching Reform of Mechanical Design Basis Course

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Abstract: Despite a series of reforms in recent years, teaching model has gained a lot of experience and lessons, but the teacher-centered undergraduate teaching model is still a mainstream phenomenon. In response to this phenomenon, the blended teaching mode of the mechanical design basis Course was studied. The research emphasized the main position of students, and completely changed the teaching mode of "teacher-centered" into "student-centered", which can improve the teaching quality and cultivate high-quality application-oriented talents with engineering application ability.

1. Introduction

Mechanical design basis is an important technical basic course for engineering majors in colleges and universities. It is the comprehensive application of multi-disciplinary theoretical and practical knowledge. It is one of the four pillar courses of mechanical majors and plays a key role in connecting the preceding and the following in the professional knowledge system [1-3]. This course mainly studies the working principles, structural characteristics, basic design theories and calculation methods of common mechanisms and common parts in machinery, and plays a very important role in cultivating students' engineering application ability. The Opinions on the Implementation of First-class Undergraduate Course Construction issued by the Ministry of Education in 2019 pointed out that the blended teaching mode referred to a course that combines online learning resources such as MOKE, intelligent teaching software and other online interactive tools with offline physical classes to carry out online and offline teaching and learning activities, mainly including: the blending of teaching space (online+offline), the blending of teaching time (effective teaching before, during and after class) and the blending of teaching methods (traditional teaching+flipped classroom).

Despite a series of reforms in recent years, the curriculum reform has gained many experiences and lessons, but the teacher-centered undergraduate teaching model is still a mainstream phenomenon. The common problems in blended teaching are: offline teaching is still dominated by instructing, the relationship between online and offline is unclear, and offline teaching form is single. In response to the above problems, the author conducted student-centered blended teaching reform research around four aspects: digital curriculum resource construction, blended teaching content design, blended teaching process design and blended process assessment.

2. Construction of Digital Curriculum Resources

According to the characteristics of the mechanical design basis course, the construction of digital learning resources is mainly to add learning materials, such as text, animation, video, VR virtual simulation experiment teaching platform, etc. Course micro-video is a very important learning resource. Teachers can record important knowledge points for no more than 15 minutes. It should be vivid and specific. Students can watch it repeatedly to deepen their understanding and mastery of knowledge points. The teachers should record micro-class videos personally, because the teachers are more familiar with their students' characteristics and the degree of mastery of knowledge points. At the same time, they can pull in the sense of distance with students and improve the learning effect of students. The animation repository should be rich, covering common mechanisms (linkage mechanism, cam mechanism, gear structure, intermittent motion mechanism) and three major types of parts (connecting parts, transmission parts, shafting parts), and the animation should be hyperlinked with relevant knowledge points in the PPT. Through the animation demonstration, students can more intuitively see the internal structure, working principle, transmission route, etc. of the machinery, and increase students' interest in learning and the head rate in class. The traditional experimental teaching has high cost, long experimental period and can only be carried out offline. These factors seriously restrict the better development of the basic experimental teaching of mechanical design. However, the construction of the basic simulation experimental project of mechanical design can bring new teaching modes and learning methods to teaching. The VR virtual simulation experiment software enables the mechanical parts to have a three-dimensional representation. The interactive operation strengthens the students' grasp of the experimental principles and operating skills, and improves the experimental teaching effect. Therefore, strengthening the construction of digital curriculum resources is a very important basis for the development of blended teaching.

3. Blended Teaching Content Design

With the progress of the curriculum reform, the class hours of the mechanical design basis course have been compressed to 56, and the new knowledge in the field of machinery is still increasing. The traditional offline teaching can’t fully meet the requirements of the course teaching, so the teaching content should be reconstructed according to the principle of "less but better". The content of the mechanical design basis course is divided into seven modules: mechanism structure analysis, mechanism motion analysis, common structure, mechanism force analysis, connecting parts, transmission parts, shafting parts, etc. both offline and online teaching hours are allocated. For knowledge points that are relatively easy to understand, students can learn online by themselves through the micro-video recorded by the teacher and by using the learning platforms such as university students' MOKE. For the content that is difficult to understand, the teacher conducts offline teaching. The mixed teaching content and class hour distribution are shown in Table 1.

Table 1: Blended teaching content design

No.	Knowledge module	Teaching content	Online class hours	offline class hours
1	Mechanism structure analysis	Kinematic sketch of planar mechanism, Degree of freedom of planar mechanism	2	3
2	Mechanism motion analysis	Velocity instantaneous center and its application in velocity analysis	1	1
3	Common structure	Planar linkage mechanisms, Cam mechanism, Gear structure, Gear train, Intermittent motion mechanism	6	8
4	Mechanism force analysis	Adjustment of mechanical running speed fluctuation, balance of rotating parts	1	3
5	Connecting parts	Threaded connection, key connection, pin connection	3	5
6	Transmission parts	Gear drive, Worm drive, belt drive, chain drive	6	8
7	Shafting parts	Shaft, bearing, coupling, clutch, brake	3	6
	Total		22	34

4. Blended Teaching Process Design

Under the current "Internet plus" education background, the reform direction should be to adopt online and offline smart classes and highlight the "student-centered" teaching model. In the process of teaching, teachers and students can make full use of online resources such as digital course resources, as well as software such as flipped campus to conduct online and offline blended teaching. The blended teaching process design of the intelligent classroom of the mechanical design basis course is as follows.

4.1. Teaching Online

Before class, the teacher established the “WeChat” course group of mechanical design basis, and established the knowledge point database corresponding to the course on the flipped campus. Then, the teacher pushes the recorded course micro-video, and uses the learning platform to release the course review and preview tasks, so that students can learn independently online and complete the learning tasks. Teachers use the flipped campus platform to test, complete the learning situation detection, determine the student preview situation according to the platform statistics, and then determine the key and difficult points of teaching. For example, in the knowledge module of "mechanism structure analysis", it is determined that the drawing of mechanism motion diagram and the calculation of mechanism freedom are the key and difficult points in teaching. Some students with learning difficulties can communicate with teachers and classmates in “WeChat” course group and solve relevant problems.

4.2. Teaching Offline

In the offline class, the teacher explains the common problems and difficult points existed online, and use the mind map to summarize the key and difficult points of knowledge. The mind map can

clearly show the key and difficult points of the content of this chapter and the structural level of the knowledge points to the students, which is bound to enhance the participation of students, stimulate the cultivation of students' systematic thinking, and can be used as an effective tool for teaching and learning [4-6]. At the same time, teachers should flexibly use various teaching methods in the process of explanation, such as engineering case teaching, project-based teaching, physical model teaching, multimedia animation projection teaching, etc [7]. In the teaching process, in order to highlight the main position of students and develop their subjective initiative, students are divided into several study groups. The teacher arranges discussion topics, the students conduct discussions, and the group representatives report on the stage. Finally, the teacher commented and summarized, and expanded the knowledge. The results of class group discussion are included in the final final examination, and the specific calculation method can be obtained by formula (1) and formula (2).

$$\text{Class discussion score} = \text{student group score} \times \text{Individual contribution coefficient} \quad (1)$$

$$\text{Student group score} = (\text{teacher evaluation score} + \text{group mutual evaluation score})/2 \quad (2)$$

In formula (1), the contribution coefficient of each group member is determined according to the division of tasks and the quality and quantity of tasks completed by the individual in the team, and the weight of the individual contribution coefficient is given by the group leader and publicized in the group.

The design of discussion topics in class is shown in Table 2, and the student-centered online and offline blended teaching process is shown in Figure 1.

Table 2: Design of in-class discussion content

No.	Discussion topics
1	Speed analysis of cam mechanism and gear mechanism by using speed instantaneous center method.
2	Analyze the design scheme of the simple punch, draw the schematic diagram of the structure, analyze whether the design intent can be achieved, and propose the modification scheme.
3	The parameters of the modified gear and the application of the modified transmission.
4	Function of gear train and specific application examples.
5	Analyze the meaning of static balance and dynamic balance of rigid rotor and the dialectical relationship between them with examples.
6	Self-locking condition of screw pair and meaning of mechanical property grade of bolt.
7	Various failure modes of gear and selection principle of gear strength design criteria.
8	Application occasions and differences of V-belt and synchronous belt.
9	Mechanical transmission scheme layout and application situation comparison.
10	Structural design of high-speed shaft and low-speed shaft in reducer.
11	Application and selection of ball bearing and roller bearing and bearing combination design.

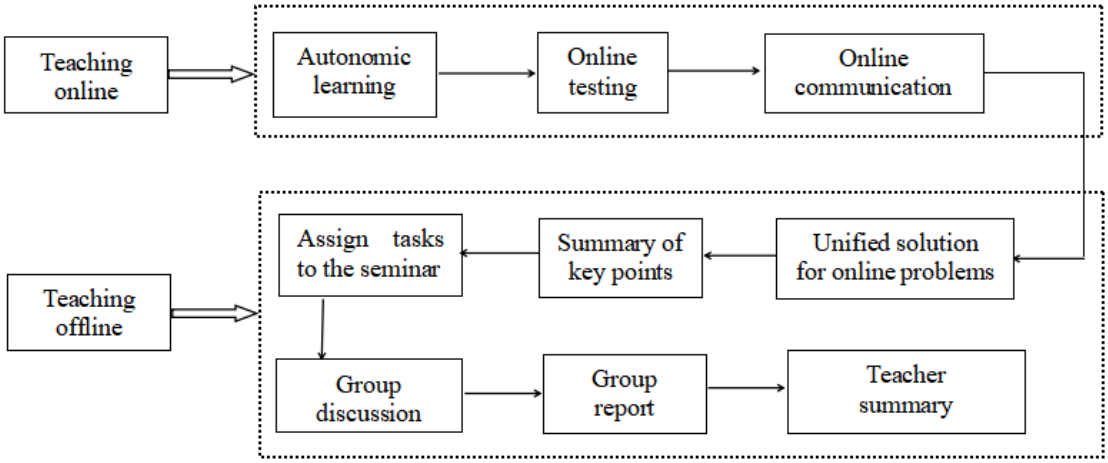

Figure 1: Blended online and offline teaching process

5. Blended Process Assessment

The traditional assessment method is based on the final examination, supplemented by the usual attendance records and homework results, which is not comprehensive enough for students. Many students make a copy of their homework at ordinary times and they "crammed" to review their homework before the exam, but the final results of this kind of students are also good. Obviously, such an assessment is not comprehensive. Therefore, the author tries to conduct process assessment, combining online and offline assessment. The final exam score consists of the online unit test score, the comprehensive homework score, the course experiment score, the in-class and off-class discussions score, the quality development score and the final exam score. The online unit test is conducted on the platform of “flipped campus” and “rain classroom”, and the results are very objective. The comprehensive homework score is calculated by the average score of the teacher each time. The experimental results consist of the experimental report and the experimental defense. The quality development is composed of papers and patents published by students and various college students' projects. Such a blended process assessment method can give a comprehensive evaluation of students' learning effects, which truly make the assessment results become the baton for evaluating students' learning effects. The evaluation method and index weight are shown in Table 3.

Table 3: Assessment and evaluation method and weight

No.	Assessment method	Weight (%)
1	Test online unit	10
2	Comprehensive homework	10
3	Course experiment	10
4	Discussions in-class and off-class	10
5	Quality development	10
6	Final exam	50

6. Conclusions

The purpose of online and offline blended teaching is to optimize the course learning method, make reasonable use of the learning time, highlight the main position of students and completely change the teaching mode centered on "teacher teaching" into "student learning", which can realize high-level learning, create "hybrid courses", and cultivate high-quality application-oriented talents with engineering application ability. The blended teaching mode is worth further practice and exploration in the teaching reform of the mechanical design basis course.

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