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Exploration and Practice of Online-Offline Blended Teaching Model in Mechanical Principles Course

Qin Dong[a,*], Enqi Wu[b]

School of Mechanical Engineering, University of Shanghai for Science and Technology, Shanghai, China
[a]dongqin@usst.edu.cn, [b]wuenqi@usst.edu.cn
[*]Corresponding author

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Abstract: With the development of information technology, the blended teaching model has become a new trend in the reform of higher education. This paper explores and practices the application of the blended teaching model in the mechanical principles course. By analyzing the characteristics of the course, suitable blended teaching content and methods are designed, and a corresponding teaching evaluation system is constructed. The research results show that the blended teaching model can improve students' learning efficiency and teaching quality. The goal of this study is to provide a theoretical basis and practical guidance for the teaching reform of the mechanical principles course and to promote the comprehensive development of students.

1. Introduction

The rapid development of information technology is leading to a profound transformation in the field of education. The blended teaching model, which combines traditional classroom teaching with modern online learning, has become a new trend in the reform of higher education [1, 2]. This model integrates online and offline teaching resources and activities, providing students with a more flexible and personalized learning experience, thereby significantly enhancing teaching efficiency and quality. The blended teaching model features flexibility, personalization, interactivity, and integration, meeting the learning needs of different students and strengthening the interactivity and effectiveness of teaching, providing students with a richer and more diverse learning path.

As one of the core courses in mechanical design and manufacturing automation, the mechanical principles course plays a crucial role. It provides students with the basic theory of mechanical design and analysis, enabling them to master the kinematics and dynamics analysis of mechanical systems, understand the working principles and design methods of mechanical components, and learn to use related engineering software for design and simulation [3, 4]. This knowledge and skills are of great significance for students' future engineering practice and innovative activities. However, the limitations of traditional teaching models, such as limited class time, single teaching resources, and lack of personalized teaching, restrict students' learning efficiency and depth [5-7]. To address these issues and improve teaching effectiveness, this study proposes a blended teaching model, expecting to optimize the allocation of teaching resources, innovate teaching activities, and establish a scientific and reasonable teaching evaluation system through the combination of online and offline methods.

The main goal of this study is to explore and practice the blended teaching model of the mechanical principles course, aiming to achieve the following objectives: first, to design a set of blended teaching content and methods suitable for the characteristics of the mechanical principles course; second, to construct a scientific and reasonable teaching evaluation system to assess the effectiveness of the blended teaching model; and finally, to propose improvement suggestions to optimize the blended teaching model, improve teaching quality, and enhance students' learning outcomes. Through this study, it is expected to provide a theoretical basis and practical guidance for the teaching reform of the mechanical principles course, promote the comprehensive development of students, and provide references and references for the blended teaching of other engineering courses.

2. Analysis of the Characteristics of the Mechanical Principles Course

2.1. Course Content

The mechanical principles course is a fundamental course in the field of engineering, providing students with the basic theories of mechanical design and analysis. The course uses the ninth edition of mechanical principles edited by Sun Huan and Ge Wenjie from Northwestern Polytechnical University of China.The organizational structure of the course content is shown in Figure 1, and the main content includes:

Introduction: Introducing the research objects, content, tasks, and development history of the mechanical principles course to establish a macro understanding of the course for students.

Structural analysis of mechanisms: Discussing the composition and structural characteristics of **mechanical** mechanisms to lay a foundation for subsequent analysis.

Kinematic analysis of planar mechanisms: Teaching students how to analyze and calculate the kinematic characteristics of planar mechanisms.

Mechanical balance: Discussing the balance issues of machinery during motion and their solutions.

Operation and speed fluctuation regulation of machinery: Analyzing the causes of speed fluctuations during machinery operation and methods of regulation.

Linkage mechanisms and their design: Explaining the working principles and design methods of linkage mechanisms.

Cam mechanisms and their design: Introducing the characteristics, types, and design processes of cam mechanisms.

Gear mechanisms **and their design**: Detailed analysis of the types, working principles, and design calculation methods of gear mechanisms.

Gear systems and their design: Discussing the calculation of gear system transmission ratios, type selection, and design principles.

Other common mechanisms and design of mechanical transmission system schemes: Introducing other mechanism types in addition to the aforementioned, as well as how to design mechanical transmission systems.

2.2. Course Objectives

The course objectives are divided into three levels: knowledge objectives, ability objectives, and quality objectives:

(1) **Knowledge Objectives:** Students are required to accurately draw schematic diagrams of planar mechanisms and calculate their degrees of freedom. They should understand the basic methods of mechanism motion analysis, comprehend the operation and speed fluctuation regulation of machinery, and grasp the working principles of commonly used mechanical mechanisms as well as the fundamental theories and methods in mechanism design.

(2) **Ability Objectives:** Students are expected to apply knowledge of mechanical principles to correctly describe engineering problems in the field of machinery. They should apply the relevant theories of mechanism design and motion analysis to analyze and judge practical problems in mechanical engineering, and gradually develop a comprehensive approach to solving engineering problems in the field by integrating relevant knowledge and methods.

(3) **Quality Objectives:** Students are expected to understand and gradually establish a correct engineering perspective and possess an awareness of innovation. They should enhance their sense of responsibility and mission to explore the unknown, pursue truth and strive for the pinnacle of scientific achievement, while cultivating a rigorous and meticulous craftsmanship spirit that strives for perfection.

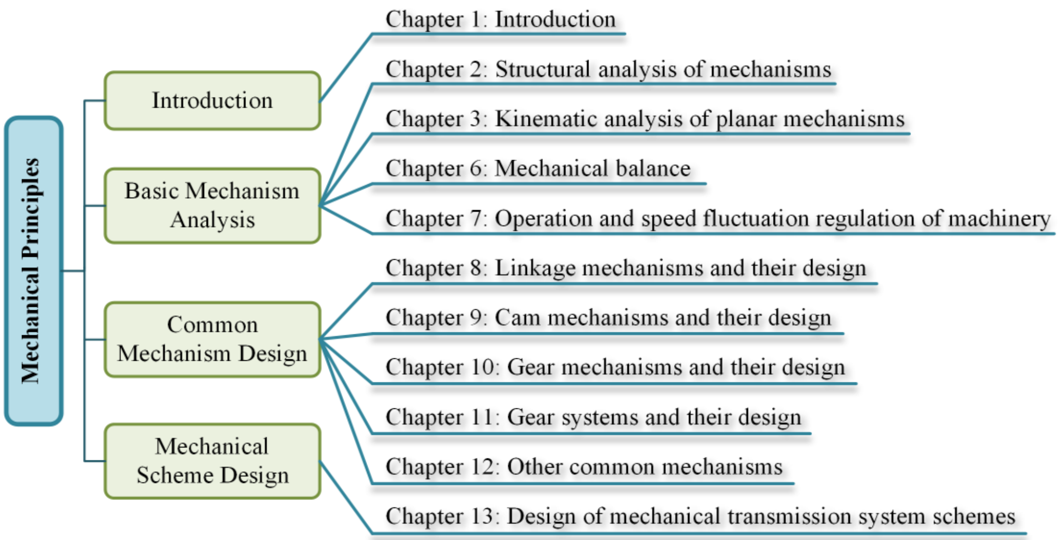

Figure 1: The course content architecture of mechanical principles

2.3. Student Needs and Challenges

When studying mechanical principles, students need teachers to provide clear theoretical guidance and sufficient practical opportunities. They need to understand abstract mechanical concepts and apply them to specific mechanical designs. In addition, students also need to master mathematical tools, such as calculus and linear algebra, which are essential for a deep understanding of mechanical principles.

The challenges students face when learning mechanical principles include:

(1) **Integration of Theory and Practice**: Students need to combine abstract theoretical knowledge with specific engineering practices, which requires them not only to understand the basic concepts of mechanical principles but also to learn how to apply these concepts to solve practical engineering problems.

(2) **Extensiveness and Depth of Knowledge Points**: The mechanical principles course covers a wide range of knowledge points, and students need to effectively connect these knowledge points to form a systematic knowledge system, while also needing to deeply understand each knowledge

point to ensure flexible application.

(3) **Cultivation of Innovative Thinking**: Students often focus on digesting classroom content and completing course tasks during the learning process, and it is difficult to achieve innovative cognitive breakthroughs and discoveries inside and outside the classroom. It is necessary to encourage students to use the theoretical knowledge they have learned to solve mechanical engineering problems through the combination and variation of mechanisms, and to cultivate innovative thinking.

(4) **Stimulating Learning Interest**: Since the mechanism graphics in the textbooks are usually simplified and static, it is difficult to directly associate them with actual machines, and students may feel bored, so stimulating students' learning interest and motivation is a challenge.

3. Design of Blended Teaching Content for Mechanical Principles Course

In the mechanical principles course, the design of blended teaching content aims to achieve a deep integration of theoretical knowledge and practical skills through a combination of online and offline methods. The following is the blended teaching design for the content of the mechanical principles course:

3.1. Online Teaching Content Distribution

Introduction: Pre-recorded videos for the introductory section are provided through an online platform, which mainly introduce the research objects, content, tasks, and the development history of the Mechanical Principles course. The video includes rich historical cases and modern application examples to help students establish a macro understanding of the course.

Structural analysis of mechanisms: Online resources include theoretical explanation videos and interactive exercises for structural analysis, guiding students to understand the composition and structural characteristics of mechanical mechanisms.

Kinematic analysis of planar mechanisms: Online animation simulations and simulation software are provided to help students understand the kinematic characteristics of planar mechanisms and perform basic motion analysis calculations.

Mechanical balance: Online resources include video explanations of balance theory and online tests, as well as case analyses, discussing the balance issues of machinery during motion and their solutions.

Operation and speed fluctuation regulation of machinery: Online video explanations of operation principles and interactive simulations are provided to analyze the causes of speed fluctuations during machinery operation and methods of regulation.

Linkage mechanisms and their design: Online animation demonstrations of the working principles of linkage mechanisms and video explanations of design methods are provided, as well as online design tools.

Cam mechanisms and their design: Online resources include video explanations of the types, characteristics, and design processes of cam mechanisms, as well as online design simulation software.

Gear mechanisms and their design: Online video explanations of the working principles of gear mechanisms and interactive teaching modules for design calculation methods are provided.

Gear systems and their design: Online resources include video explanations of gear system transmission ratio calculations and online design tools, as well as explanations of type selection and design principles.

Other common mechanisms and design of mechanical transmission system schemes:

Online introduction videos of other mechanism types and case analyses of mechanical transmission system design are provided.

3.2. Arrangement of Offline Teaching Activities

(1) **Laboratory operation:** Students carry out the assembly and testing of mechanisms in the laboratory, such as linkage mechanisms, cam mechanisms, and gear mechanisms, to practice and verify the theoretical knowledge learned online.

(2) **Group discussion:** Students are organized into small groups to discuss the content learned online in depth, including structural analysis and kinematic analysis of mechanisms, as well as balance issues.

(3) **Flipped classroom:** In the classroom, teachers guide students to discuss the content learned online, address student questions, and conduct in-depth case analyses.

(4) **Design project:** Students undertake design projects offline, such as designing a simple mechanical transmission system, applying the theoretical knowledge learned online to solve practical problems.

(5) **Competition topic discussion:** The course incorporates competition topics from mechanical innovation design contests to stimulate students' interest in learning, guide them to study actively, and conduct discussions and project design offline.

4. Blended Teaching Methods of Mechanical Principles Course

The application of blended teaching methods in the mechanical principles course aims to improve teaching effectiveness and students' learning experience by combining the advantages of online and offline teaching. Figure 2 presents the online-offline blended teaching process of mechanical principles course. The blended teaching methods involved are as follows:

(1) **Flipped classroom**: Students preview the course content through online platforms such as MOOC or specialized course websites before class, including watching recorded video lectures, reading electronic textbooks, and participating in online discussions. In the classroom, teachers focus on discussion, problem-solving, and practical application, thereby improving students' participation and understanding.

(2) **Project-driven learning**: Real engineering project topics related to mechanical principles are posted on the online platform, where students can accept tasks online and then carry out group discussions and actual operations offline. This method helps students apply theoretical knowledge to solve practical problems, enhancing the practicality and specificity of learning.

(3) **Case analysis**: Online resources can provide a wealth of application cases of mechanical principles, and students can preview and analyze these cases online. In the offline classroom, teachers guide students to discuss in depth, combining theoretical knowledge with practical engineering problems, and improve students' ability to analyze and solve problems.

(4) **Interactive simulation**: Using online simulation software, students can simulate the operation of mechanical systems online, such as the motion simulation of gear mechanisms and cam mechanisms. This simulation activity can enhance students' intuitive understanding and provide a theoretical basis for offline experimental operations.

(5) **Laboratory operation and application of digital tools**: Offline laboratory operation is an indispensable part of the mechanical principles course. Students carry out the assembly and testing of mechanisms in the laboratory, and at the same time, teachers can introduce digital tools such as 3D printing and laser cutting to assist students in design and manufacturing.

(6) **Online testing and feedback**: The online platform can be used for immediate quizzes and feedback, helping students to understand their learning situation in a timely manner. Teachers can

also adjust teaching strategies through the results of online tests to meet students' learning needs.

(7) **Collaborative learning**: The online platform can provide a space for collaborative learning, where students can form learning groups online and complete learning tasks together, such as designing a mechanical system or analyzing a complex mechanical motion problem.

(8) **Formative evaluation**: The blended teaching model emphasizes formative evaluation, and teachers can track students' learning progress through the online platform, including their online learning time, participation, and completion of assignments, to assess students' learning outcomes.

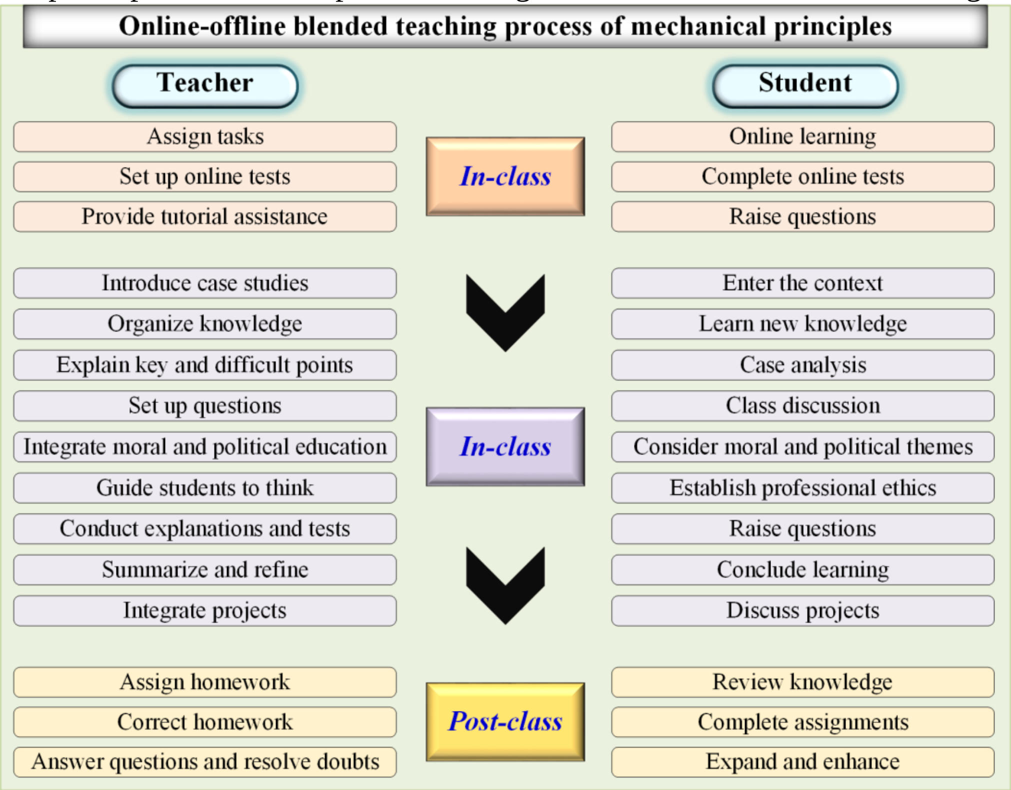

Figure 2: Online-offline blended teaching process of mechanical principles course

5. Blended Teaching Evaluation System of Mechanical Principles Course

5.1. Design Principles

The design of the evaluation system follows the following principles:

Comprehensiveness: The evaluation should cover all key components of the course, including online learning, offline practice, student interaction, and learning outcomes.

Fairness: The evaluation criteria should be objective and transparent, ensuring that all students are treated fairly in the evaluation process.

Development: The evaluation should not only focus on current learning outcomes but also on the long-term development and progress of students' learning.

Diversity: A combination of various evaluation methods, including self-evaluation, peer evaluation, teacher evaluation, and expert evaluation.

5.2. Evaluation Indicators

The evaluation indicators include:

(1) **Online learning participation:** This is primarily monitored through the online platform by

tracking students' learning activities, such as the number of video views, participation in discussion forums, and scores on online tests (as shown in Figure 3). AI technology can assist in analyzing this data, identifying students' learning patterns and behavioral habits.

(2) **Offline classroom performance:** Teachers evaluate students based on their interaction, response to questions, and participation in group discussions within the classroom. AI-assisted classroom observation tools can capture students' level of participation and interaction.

(3) **Homework and project completion quality:** This primarily involves assessing the accuracy, innovation, and engineering practice capabilities reflected in the homework and project reports submitted by students. AI-assisted automatic scoring systems can evaluate the accuracy and completeness of the homework.

(4) **Integration of theory and practice:** This refers to the ability to apply theoretical knowledge to practical problems through case analysis and design projects.

(5) **Independent learning ability:** This refers to the evaluation based on students' study plans, self-assessments, and utilization of learning resources.

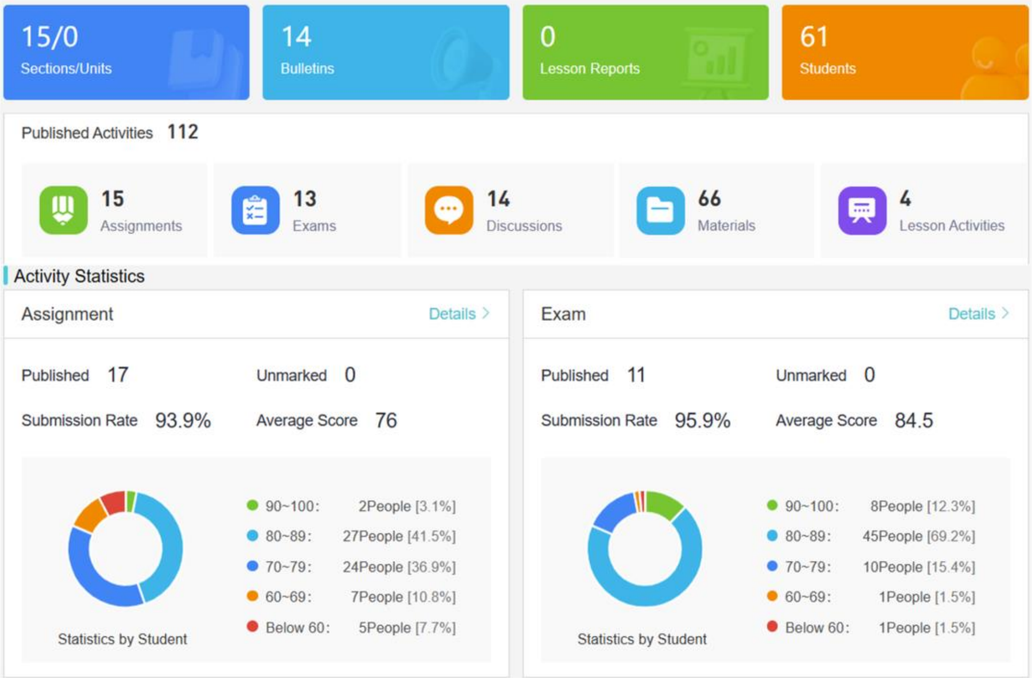

Figure 3: Online platform and part activity statistics of mechanical principles course

5.3. Methods of Collecting Feedback

Quantitative methods: This refers to the use of data analysis tools on online learning platforms to collect students' learning behavior data for quantitative analysis. AI technology can be used to explore patterns and trends behind the data.

Qualitative methods: This involves gathering subjective feedback from students and reflections on teaching through surveys, interviews, and classroom observations.

5.4. Using Evaluation Results to Improve Teaching

Evaluation results will be used for:

(1) **Adjusting teaching content:** The depth of theoretical explanations and the design of practical sessions will be adjusted based on the students' level of understanding and their feedback.

(2) **Improving teaching methods:** Online resources and offline teaching activities will be

optimized according to the students' learning habits and preferences.

(3) **Enhancing student support:** Additional tutoring and resources will be provided for students who struggle with their studies, and more in-depth learning opportunities will be offered to high-achieving students.

6. Conclusions

Through the exploration and practice of this study, the application of the blended teaching model in the mechanical principles course has proven its significant advantages in improving teaching effectiveness and students' learning experience. The model integrates online independent learning with offline interactive discussions, not only optimizing the allocation of teaching resources but also innovating teaching activities, making teaching more flexible and personalized. In addition, the established evaluation system provides reliable feedback and guidance for the improvement of teaching quality, ensuring the effectiveness and relevance of teaching activities. In the future, research should continue to focus on optimizing the blended teaching model to adapt to the ever-changing educational needs and technological advancements. Through continuous exploration and innovation, the blended teaching model is expected to bring more teaching reforms and innovations to the field of engineering education, providing a solid teaching support for cultivating engineering talents who can adapt to future challenges.

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