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Computer Animation Assisted Teaching Software System for Theory of Machines and Mechanisms

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Abstract: The purpose of this article is to design and implement a computer-aided teaching software system for mechanical principles, which dynamically displays the principles of mechanical motion and improves teaching quality and learning efficiency. This study first analyzes the problems existing in the current teaching of mechanical principles, and then comprehensively applies knowledge such as computer graphics, animation design, and educational psychology to design a computer animation teaching software system that meets the needs of mechanical principle teaching. Finally, this article verifies the effectiveness of the system through experiments. This study explores the impact of computer-assisted animation teaching on the learning effectiveness of mechanical principles courses. During the experimental stage, four experiments were conducted to evaluate the changes in four aspects: learning interest, understanding depth, memory retention, and practical application ability. In the teaching effectiveness evaluation experiment, the average score of the experimental group of students using mechanical principle computer animation assisted teaching software was 89.9 points. In the deep understanding assessment experiment, the average number of correct answers among the experimental group students was 4.3. In the memory retention assessment experiment, the average score of the experimental group in the short-term memory retention test was 8 points. In the practical application ability evaluation experiment, the average score of the experimental group on all evaluation indicators was higher than that of the control group. From the above data conclusions, it can be seen that computer animation assisted teaching has significant effects in improving students' learning interest, deepening understanding, strengthening memory retention, and enhancing practical application abilities.

1. Introduction

The rapid development of information technology has made computer-aided teaching popular in the education industry, especially in its use in engineering and technical education. As one of the core disciplines of engineering, the teaching quality of mechanical principles directly affects students' ability to solve practical problems in the future. However, traditional teaching methods have shown significant shortcomings in teaching complex mechanical concepts and principles, making it difficult to arouse students' interest and facilitate their understanding and memory. In view of this situation, this study focuses on exploring the application of animation teaching in mechanical principles courses, with the aim of using computer animation to enhance teaching effectiveness, including stimulating students' interest in learning, deepening understanding, improving memory, and enhancing practical operational abilities.

In this study, four specific experiments were conducted to comprehensively test the role of computer-assisted animation teaching in improving the learning effect of mechanical principles. The research results show that compared to traditional teaching, using computer animation as an auxiliary tool can significantly improve student performance in these key areas. This discovery not only proves the effectiveness of computer animation in teaching mechanical principles, but also provides educators with a new teaching tool to help students comprehensively improve.

The beginning of this article introduces the background and significance of the research, and in the methodology stage, this article introduces system requirement analysis, interface design interaction, and animation demonstration development. Subsequently, in the experimental stage, this article compares the differences between computer-assisted teaching and traditional teaching methods in different evaluation criteria, and conducts in-depth discussions on these results. In the conclusion section of the article, the significance of these findings for educational practice is explored, and future research directions are proposed. The layout of the entire article is to present the research process and results clearly and easily for readers to understand and apply.

2. Related Works

Over the past few decades, numerous researchers have made contributions in the field of computer-aided teaching. For example, in order to improve the control accuracy of virtual simulation systems, Wang Longting et al. adopted incremental control algorithms. This algorithm can adjust the sampling signal and sampling period as needed in a timely manner, thereby more accurately controlling the operation of the virtual device [1]. Regarding the certification of engineering education in the field of mechanical manufacturing and automation, Wang Lei proposed the construction and reform of an engineering practice teaching system under the background of engineering education [2]. Existing research mainly focuses on students' perspectives on learning, rather than actual learning outcomes. Yadav A described a survey on the impact of case-based teaching on the conceptual understanding of undergraduate mechanical engineering students and their attitudes towards case studies [3]. Alves J L introduced a project called "Production of Ceramic Components", specifically designed for students in the first semester of the third year of the Mechanical Engineering course. Students believed that this project could help them improve their soft skills and better prepare for their future careers [4]. Rui Z used his engineering courses "Introduction to Mechanical Engineering" and "Mechanical Processing Technology" taught at the International School of Beihang University as an example to systematically analyze the current situation and background of international student education [5]. These studies show that dynamic visual aids can significantly enhance students' learning interest and understanding depth. However, despite the progress made in these studies, there are still some issues, such as insufficient interactivity of software systems, difficulties in updating content, and a lack of targeted teaching strategies.

In response to the above issues, some studies attempt to introduce more advanced technologies and teaching concepts. For example, Vlah D's research explored the usefulness of existing VR

(Virtual Reality) 3D modeling tools in mechanical engineering. His research found that using VR tools could quickly create complex part geometries [6]. Jose Luis Martín Núez focused on how artificial intelligence technology supported the teaching process of engineering and provided a detailed description of how to quickly introduce artificial intelligence into any engineering course [7]. Gan Guoqiang et al. explored educational reform using VR virtual reality technology to address the problems in course experiments, graduation internships, and production internships in engineering practical teaching [8]. Xiu Yun et al. analyzed the shortcomings in the teaching of the "Introduction to Mechanical Engineering" course and proposed a conceptual course objective based on the requirements for cultivating engineering literacy among students majoring in mechanical engineering, as well as the support for graduation requirements in the course [9]. Based on the talent cultivation of mechanical engineering at Zhengzhou University of Light Industry, Zhang Yuyan et al. constructed talent cultivation goals under the background of intelligent manufacturing, aiming to explore an artificial intelligence course teaching mode that met the needs of mechanical engineering [10]. These methods have to some extent improved the interactivity and adaptability of teaching software, but still face challenges such as high costs and high technical requirements. In addition, these studies often lack long-term tracking and evaluation of student learning outcomes, making the sustainability and stability of teaching effectiveness questionable.

3. Methods

3.1 System Requirements Analysis

The design of this system focuses on assisting in teaching mechanical principles, so it is crucial to work closely with educational experts in the field of mechanical engineering to conduct a needs analysis of teaching content. The goal is to clarify which core concepts and principles are most suitable for computer animation display, such as mechanical motion, force transmission, and mechanical efficiency, in order to develop intuitive animations to help students break through the limitations of traditional teaching and improve learning efficiency. The system is mainly aimed at students majoring in mechanical engineering in higher education institutions. Although this group has certain basic knowledge, they still need an intuitive and interactive learning approach when facing complex concepts. Therefore, the system is designed to be easy to use, user-friendly, and able to provide personalized learning paths to adapt to different learning speeds and styles. To meet the diversity of target user groups, the system supports various devices and operating systems, including Windows, while considering the needs of online teaching. It supports online access and use, making it easy for teachers to remotely manage teaching content. Students can also access learning resources from anywhere with a network. The ease of use is crucial, therefore the system provides an intuitive user interface design, simplifies resource access and management, and includes comprehensive help support, such as tutorials, to ensure that users can quickly solve problems. In the system requirements analysis phase, a key task is to determine the maximum number of users and corresponding resource requirements that the system needs to process. Formula (1) can be used to represent:

$$\mathrm{R} = U \times (M + B) \tag{1}$$

In formula (1), Rrepresents the system resource requirement, U is the maximum number of concurrent users, M is the average memory requirement per user, and the amount of memory required for the basic system to run is B. Through the above system requirements analysis, it can be ensured that the developed mechanical principle computer animation assisted teaching software system can meet the needs of teachers and students, improve teaching and learning efficiency, and ultimately achieve the goal of optimizing the teaching process and improving learning effectiveness [11-12].

3.2 Interface Design and Interaction

The interface design of this system adheres to the three key principles of intuitiveness, ease of use, and interactivity, with the aim of creating a clear and user-friendly environment for users, while stimulating students' interest in learning and improving the teaching efficiency of teachers. The software interface is characterized by a concise and clear layout, allowing users to quickly locate the required functions and information. On the main interface, various mechanical principles animation resources are clearly displayed by category, and users can search or browse to find animations on specific themes. The animation playback interface is equipped with simple playback control buttons, such as play, pause, stop, and fast forward/rewind, allowing users to control the animation according to their own learning speed. In order to make learning more interactive and interesting, the animation is accompanied by relevant theoretical knowledge prompts and interactive practice questions, encouraging students to take knowledge tests and enhance understanding while watching the animation [13].

On the teacher side, the system provides an easy-to-use content management interface for teachers. Through this interface, teachers can easily upload new teaching animations, edit detailed information of existing animations, and arrange teaching content. In addition, there is a learning progress tracking interface that allows teachers to view the learning progress, exam scores, and learning activity records of each student, which greatly helps teachers adjust teaching plans in a timely manner and provide customized guidance. In short, the interface design and interactive functions of this system are centered around user experience, making the software easy to operate and increasing students' learning motivation through various interactive elements. At the same time, it also provides an effective teaching management tool for teachers.

3.3 Animation Demonstration Development

The main purpose of developing animation demonstrations is to create a batch of high-quality and educational animations that provides a highly interactive experience. These animations aim to visually demonstrate the working principles and application scenarios of mechanical principles. This means that these animations not only need to visually attract students, but more importantly, they must be precise in conveying educational content, ensuring that students can easily understand and master it. The information transmission efficiency IE of animation can be expressed by formula (2):

$$\mathrm{IE} = \frac{C}{F / A} \tag{2}$$

In formula (2), the information efficiency is IE, C is the number of core concepts included in the animation, F is the total number of frames in the animation, and the average attention duration of the user is A. The goal of achieving high-quality educational animation requires interdisciplinary cooperation. Education experts and mechanical principles experts first jointly determined the teaching objectives and key concepts to ensure that the animation content has high educational value. Then, this professional knowledge is transformed into detailed scripts and animation blueprints to guide animation designers. This article utilizes advanced computer graphics technology and animation software to ensure high-quality and interactive animation. In order to make animation more vivid and understandable, this study particularly focuses on the handling of details in animation, such as the smoothness of mechanical motion and the interaction between mechanical components. The animation also integrates interactive functions, such as allowing users to click on specific parts of the animation to obtain more information or observe different stages of mechanical motion by dragging. Considering the diverse teaching needs, we have designed animations suitable for different learning stages to meet the needs of beginners to advanced learners. The animation library covers a wide range of topics on mechanical principles, providing teachers with rich teaching resources and supporting diverse teaching methods [14].

In short, the animation demonstration development process is the key to the success of the entire teaching software system. By combining professional knowledge, teaching strategies, and advanced animation technology, this article strives to create animations that are both educational and can stimulate students' interest in learning, in order to support and improve the teaching and learning process of mechanical principles [15].

4. Results and Discussion

4.1 Evaluation of Teaching Effectiveness

In this teaching effectiveness evaluation experiment, the effectiveness of computer animation assisted teaching in the field of mechanical principles was evaluated. In the experiment, students will be divided into an experimental group and a control group. The experimental group students used computer animation assisted teaching software for mechanical principles, while the control group students used traditional teaching methods. After the experiment, the difference in grades between the two groups was compared to evaluate the effectiveness of computer-assisted animation teaching.

From Figure 1, it can be seen that the average score of the experimental group students using mechanical principle computer animation assisted teaching software is 89.9 points, while the average score of the control group students using traditional teaching methods is 74.1 points. From the data conclusion, it can be seen that introducing computer animation as an auxiliary teaching tool in the teaching of mechanical principles can significantly improve students' academic performance. Therefore, integrating animation and visualization technology into the teaching process can not only enhance students' interest in learning, but also effectively enhance their learning outcomes. The specific situation is shown in Figure 1:

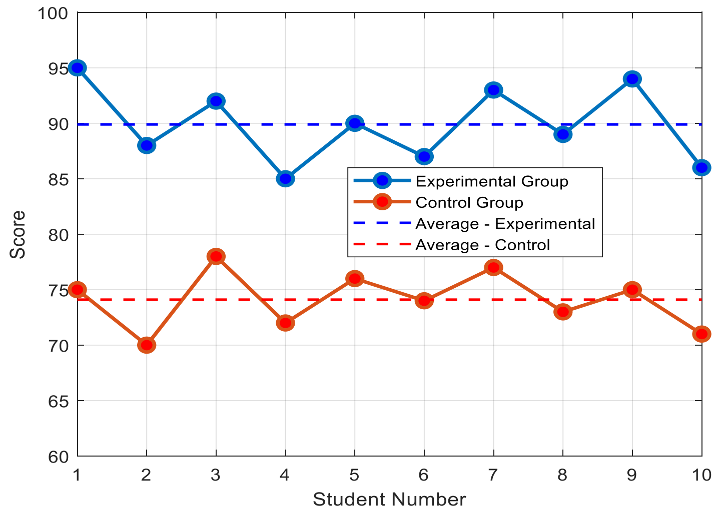

Figure 1: Evaluation of teaching effectiveness

4.2 Understanding Depth Assessment

The effectiveness of computer-assisted animation teaching in enhancing students' understanding of mechanical principles was explored in the depth assessment experiment. This study divided students into an experimental group and a control group. The experimental group students learned mechanical principles through computer-assisted animation teaching software, while the control group students used traditional teaching methods. Two groups of students receive a series of tests on mechanical principles at the end of the teaching cycle to evaluate their understanding and application ability of the knowledge they have learned. The depth can be measured using formula (3):

$$D = \frac{S_{post} - S_{pre}}{S_{pre}} \times 100\% \quad (3)$$

In formula (3), D represents the percentage improvement in understanding depth, and the student's test scores after and before teaching are S_{post} and S_{pre}, respectively. The specific data details are shown in Figure 2:

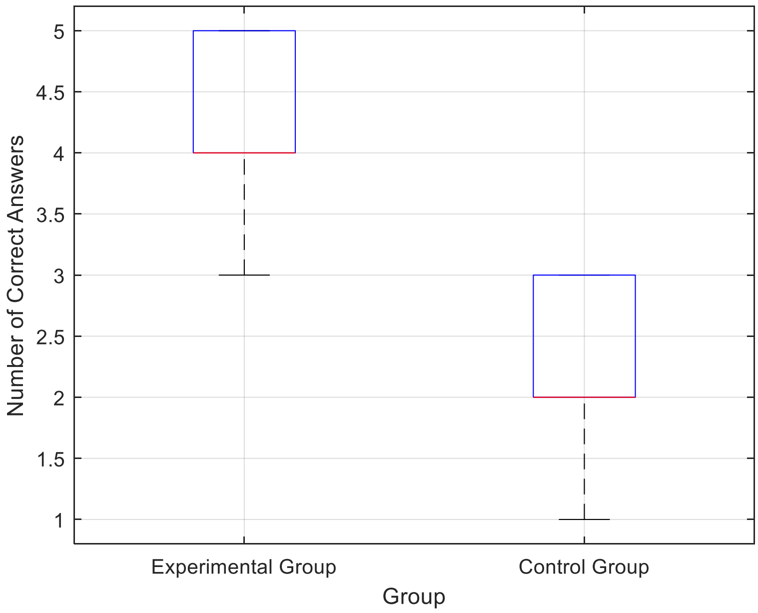

Figure 2: Understanding depth assessment

From Figure 2, it can be seen that the average number of correct answers among the experimental group students is 4.3, while the average number of correct answers among the control group is 2.3. From the data conclusion, it can be seen that computer animation assisted teaching significantly improves students' understanding depth and performance consistency in mechanical principle learning, indicating the important value of integrating such technologies into teaching strategies

4.3 Memory Retention Assessment

The memory retention assessment experiment evaluated the impact of computer-assisted animation teaching on students' memory retention and comprehension application abilities. In the experiment, short-term and long-term memory retention tests, as well as comprehension and application ability tests, were conducted on students one week and one month after the end of teaching. The experimental group of students used computer animation to assist in teaching, while the control group used traditional teaching methods. Drawing a graph of the values of the above indicators to visually demonstrate the differences in teaching effectiveness between the two groups of methods.

From Figure 3, it can be seen that the average score of the experimental group in the short-term memory retention test is 8 points, while the control group is 5.5 points; in the long-term memory retention test, the average score of the experimental group is 6.9 points, while the control group scores 4.4 points; in the comprehension application test, the experimental group also scores an average of 8 points, surpassing the control group's 5.5 points. From the conclusion of the appeal data, it can be seen that animation assisted teaching not only enhances students' immediate memory of teaching content, but also enhances their long-term retention of knowledge and ability to apply problem-solving skills. The specific data situation is shown in Figure 3:

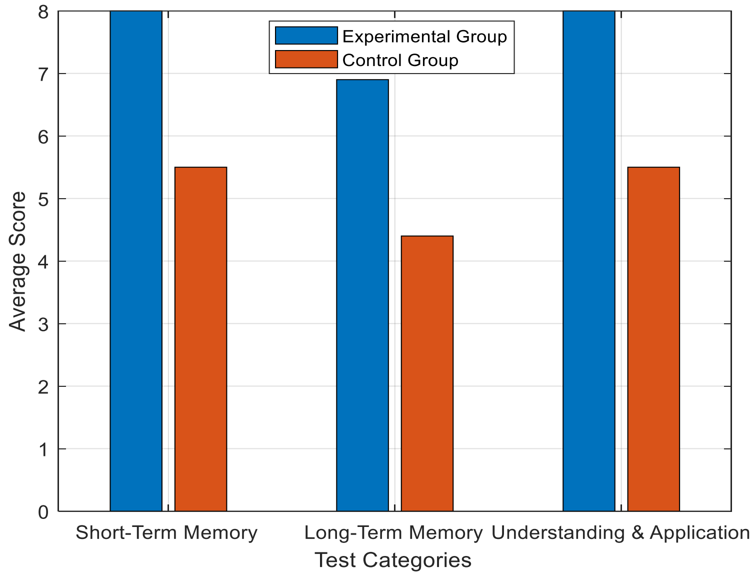

Figure 3: Memory retention assessment

4.4 Assessment of Practical Application Capability

In the practical application ability evaluation experiment, the effects of computer animation assisted teaching and traditional teaching methods on students' practical application ability were evaluated. In the experiment, attention was paid to four indicators: problem-solving efficiency, innovative thinking, the transformation from theory to practice, and team cooperation, and plot the scores of the two groups of students on these indicators into a table to compare the differences in practical application abilities between the two groups of methods. The application efficiency of students can be expressed by formula (4):

$$E = (1 - \frac{T_{post}}{T_{pre}}) \times 100\% \quad (4)$$

In formula (4), the percentage improvement in student application efficiency is E, T_{post} and T_{pre} respectively represent the time required for students to solve the same problem after and before teaching. The specific data details are shown in Table 1:

Table 1: Evaluation of Actual Application Capability

Criteria	Experimental Group Score	Control Group Score
Problem-Solving Efficiency	8.2	6
Innovative Thinking	8.4	5.3
Theory to Practice Transformation	7.8	5.6
Teamwork	8.6	6.2

From the data in Table 1, it can be seen that the experimental group scores 8.2 points in problem-solving efficiency, 8.4 points in innovative thinking, 7.8 points in the conversion index from theory to practice, and 8.6 points in the final team cooperation score. From the above data conclusions, it can be seen that computer-assisted animation teaching can significantly improve students' practical application abilities, especially in innovative thinking and teamwork.

5. Conclusion

Through computer-assisted animation teaching, this study explores the possibility of enhancing the learning effect of mechanical principles. Through the evaluation of four specific experiments, the results showed that computer animation significantly improved students' learning motivation and teaching effectiveness compared to traditional teaching methods. The experimental group outperformed the control group in various evaluation indicators, indicating that computer animation, as a teaching aid, plays an important role in helping students better understand complex mechanical principles, improve memory retention and practical application abilities. However, this study also has its limitations, such as limited sample size, which may limit the broad applicability of the research results. At the same time, there has been no in-depth study on the impact of computer-assisted animation teaching on students with different learning backgrounds and knowledge levels. Future research can expand the sample size to cover different types of learners and explore the application of computer animation in a wider range of science and engineering teaching. Further research can also consider how to combine other teaching technologies, such as virtual reality and augmented reality, with animation to improve teaching effectiveness, as well as how to use animation to enhance students' innovation and design thinking.

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