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Teaching Reform of the Mechanical Drawing Course Incorporating Computer Graphics Technology

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Abstract: With the development and popularization of computer application technology, the use of computer graphics and image processing technology has become the main means of modern engineering design and drawing. Learning and mastering 3D modeling technology and mechanical information modeling technology have become an important goal of learning engineering drawing. To meet the teaching requirements of the "New Engineering" program, higher education should cultivate innovative talents with the ability to identify, express, analyze, and solve complex engineering problems; promote the transformation of teaching methods for the course of "Mechanical Drawing and Computer Drawing" from "teaching well" to "learning well." This change is not only a change in course content, but also a change in training objectives. It introduces modern 3D design concepts into the drawing course, constructs a learning system with 3D modeling technology as the main line, solves the problem of imagination in traditional teaching, makes the learning process more in line with scientific cognitive laws, better meets the needs of modern manufacturing industry for new technologies, and improves students' drawing skills and ability to use modern tools (computer drawing).

Keywords: Mechanical drawing; 3D modeling; Project-driven; Teaching reform

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1. Introduction

Applied technology undergraduate colleges cultivate technical talents who can apply mature technologies and theories to practical production and life on the front line. Mechanical drawing is a fundamental course that engineering students in universities must study. Engineering drawings are the language of the engineering community, so this course mainly aims to cultivate students' basic drawing skills, the rules that must be followed when drawing, and the spatial imagination of innovative thinking, so that students can become qualified technical application-oriented talents after graduation. This requires students not only to be able to understand engineering drawings, but also to be able to draw them. Mechanical drawing is a fundamental knowledge necessary for students to study professional courses and design courses, and it is also the basis for

all drawing. In order to enable students to better adapt to future work, flexibly apply their knowledge, correct the shortcomings of traditional teaching models, improve the overall level of teaching courses, and better cultivate more technically application-oriented talents who can serve the front line in the future [1–3].

In modern industrial production, designers express design objects through drawings, and manufacturers process them through drawings. Drawings are known as the "technical language of the engineering world." It is an effective carrier of engineering information and a form of expression for engineering data. With the development of high-tech, technologies such as computer graphics, computer-aided design (CAD), computer-integrated manufacturing (CIM), virtual reality manufacturing (VM), scientific visualization (SV), multimedia, and computer networks have fully demonstrated the powerful functions of using graphics and images to process data. It can be foreseen that in the future, the expression of engineering design ideas and results will be mainly in the form of graphics or images, as the saying goes, "one image is worth a thousand words." Meanwhile, these technologies have changed engineering drawing techniques to varying degrees. Computer-aided design/manufacturing technology (CAD/CAM) has brought tremendous changes to engineering drawing technology, and its research content has far exceeded the scope of traditional engineering drawing studies. Many modern technologies have been introduced into traditional techniques, and computer graphics technology is also included in graphic technology. Engineering drawing technology has become one of the fundamental and key technologies in CAD/CAM. The theme of new engineering drawing technology research is how to use computer technology to quickly and effectively draw engineering drawings. In the process of national education informatization development, using computers for mapping is an inevitable need to adapt to education informatization and modernization. Introducing computer teaching systems in the classroom can enable students to have a deeper understanding of the relationship between geometry and space in design. The application of computer technology makes students more intuitive and three-dimensional in graphic expression and design, which is more conducive to students mastering the essence of graphic expression [4–7].

2. Problems in the mechanical drawing course

The course of mechanical drawing is usually scheduled for first-year study, and students do not visit enterprises or intern in school laboratories, so they have little knowledge of mechanical engineering, which affects the quality and effectiveness of teaching. The mechanical drawing course has fewer class hours but contains strong theoretical knowledge, requiring a lot of time to do exercises after class, which leads to students feeling bored and uninterested in learning this subject, with low learning enthusiasm and difficulty in cultivating students' spatial imagination. The teacher was reciting the textbook on the podium, and the students only received theoretical knowledge, but their actual surveying and mapping abilities, image reading skills, and spatial imagination were not trained. Traditional engineering graphics teaching generally uses two-dimensional design platforms for teaching, and the main problems are as follows:

(1) Traditional 2D design is only used for designing engineering drawings and cannot meet the information needs of subsequent courses such as CAE/CAM/PDM. It is easy to misunderstand the conversion process from 3D to 2D to 3D between design and manufacturing. It is also unable to express complex surfaces, with poor modeling, rendering, and animation abilities, making it difficult to provide a foundation for subsequent course graduation projects.

(2) Teaching based on two-dimensional design is time-consuming and difficult to grasp and understand.

(3) The knowledge imparted is outdated and unable to capture the characteristics of modern manufacturing technology, thus unable to meet the needs of employers.

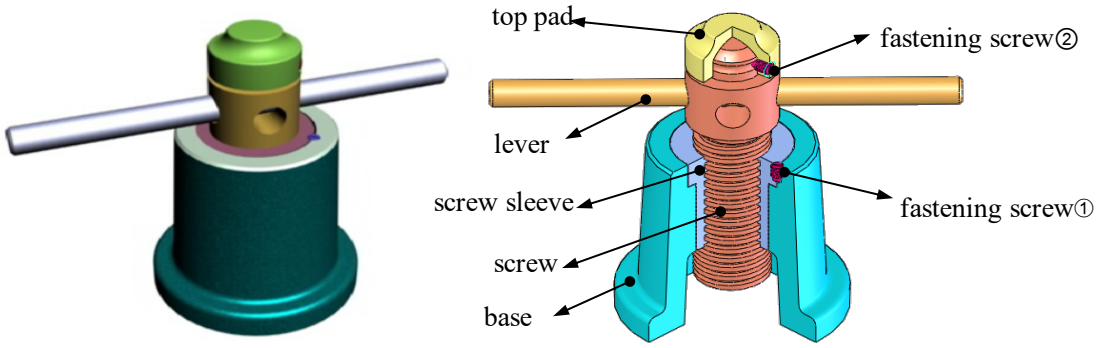
(4) The heavy workload of design, drafting, and editing makes it difficult for students to focus their main experiences on innovative design. Therefore, it is also not conducive to the cultivation of students' comprehensive innovation ability [8–10].

3. Applying 3D modeling technology to reform mechanical drawing teaching

The purpose of the teaching reform of the mechanical drawing course is to start with 3D vision, increase students' learning interest, and thus achieve the ability to proficiently read and draw drawings. The characteristic of the drawing course for mechanical majors is its strong practicality. The curriculum system is based on 3D modeling as the main line, interweaving the content of drawing, coordinating and integrating 3D software modeling methods with mechanical drawing theory knowledge, and dispersing them into various teaching chapters. This method can promote students' intuitive understanding of the structure and interrelationships of components, help establish students' spatial thinking and imagination abilities, and facilitate their understanding of drawing content [11,12].

Students first analyze the physical features and then practice 3D modeling. This can form a direct sensory understanding of the parts and cultivate an engineering graphics thinking mode that combines visual thinking and abstract thinking. Train students in the conversion between three-dimensional shapes and two-dimensional graphics, enhance their spatial imagination, and lay the foundation for learning, constructing, expressing, and recognizing body shapes in two-dimensional projection. The engineering object studied in this course is machine parts and components. Machines or components, regardless of size or shape, have certain functions, and people recognize and select components through their functions. To ensure the functionality of the components, what kind of structure is needed, that is, which types of parts are composed of? Based on the role of each part in the component, the shape of the part is designed, and its structural information is expressed in the form of engineering drawings.

By analyzing the lifting jack and understanding its structure and shape. The function of a lifting jack is to lift heavy objects. The lifting jack shown in **Figure 1(a)** uses a screw to rotate and lift a heavy object. The components of the lifting jack are shown in **Figure 1(b)**. The jack consists of 7 parts. Screw and screw sleeve achieve threaded transmission; The screw sleeve is fixed on the base by the fastening screw (1) and remains stationary; The contact surface between the top pad and the screw is a part of the sphere. When the screw rotates, the external force acting on the top pad points towards the center of the sphere to keep it stationary; The screwing position of the fastening screw (2) should ensure the flexible rotation of the screw, as well as prevent the top pad from falling off and coming into contact with the screw.



(a) lifting jack (b) The components of the lifting jack

Figure 1. Lifting jack and its components

Assembly drawing representation is an important part of engineering design, mainly expressing the mutual positional relationship (assembly relationship) between parts and assemblies to meet the functional requirements of mechanical products. Due to the overlapping relationship between multiple components, the expression of assembly drawings is complex and abstract. By utilizing the assembly function of SolidWorks and employing a bottom-up assembly design approach, students were able to gain a deep understanding of the assembly relationship through the dynamic demonstration of the jack assembly explosion in **Figure 2**, thereby fully comprehending the assembly drawings generated by the assembly. You can also rotate each view separately to obtain views from various angles, allowing students to have a clearer understanding of the shape, structure, and assembly relationship of the jack. Quickly improving students' intuitive understanding, shortening the cognitive cycle of converting three-dimensional solids to two-dimensional planes, and two-dimensional planes to three-dimensional solids, concretizing and visualizing abstract projection problems in teaching, reducing teaching difficulty, greatly stimulating students' interest in learning, and to a certain extent improving students' ability to use modern technological means. Starting from the teaching characteristics of mechanical drawing and combining the features of SolidWorks software, SolidWorks is applied in surveying practice, and a new surveying process is adopted to complete the surveying of parts and assemblies and generate engineering drawings.

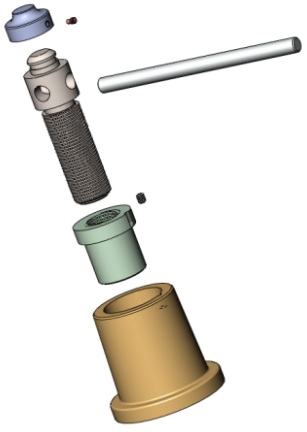


Figure 2. Explosion diagram of lifting jack

4. Future development direction and suggestions

(1) In response to the continuous development and updating of 3D modeling technology, it is recommended that teachers keep up with the latest 3D modeling software and technology in a timely manner, maintain updated and cutting-edge teaching content, and ensure that students receive the latest and most practical knowledge.

(2) Encourage students to practice more during the learning process, not only mastering basic modeling techniques, but also focusing on cultivating the ability to solve practical problems. Some practical courses or projects can be set up to continuously improve students' modeling skills and documentation abilities through practice.

(3) Promote the integration of 3D modeling technology and mechanical drawing courses, and facilitate interdisciplinary cooperation. We can collaborate with engineering, design, and other related majors to expand students' understanding and application in different fields and improve their comprehensive abilities.

(4) Strengthen the awareness and cultivation of lifelong learning among students, making them aware of the importance of 3D modeling technology in practical work, as well as the necessity of continuous learning and updating of knowledge. Relevant career planning and employment guidance courses can be set up to help students better integrate into the workplace.

(5) Encourage students to participate in relevant competitions and contests, cultivate their teamwork spirit and competitive awareness, while improving their practical skills and problem-solving abilities. This will have a positive impact on their future career development.

5. Conclusion

The promoting effect of 3D modeling technology on the teaching of mechanical drawing course:

(1) Enhance students' interest and participation in learning: Traditional mechanical drawing courses mainly focus on two-dimensional drawing, and students often have difficulty understanding the three-dimensional spatial relationships behind design drawings, resulting in low learning interest. After introducing 3D modeling technology, students can quickly understand the 3D structure of products through real-time display and interactive operation, stimulate learning interest, and improve participation.

(2) Enhance practical ability and innovative thinking: Through the use of 3D modeling software, students can simulate the design and drawing process in real engineering environments, cultivating practical operational skills and problem-solving abilities. Students can compare and optimize multiple solutions during the design process, stimulate innovative thinking, and improve their design skills.

(3) Promote interdisciplinary integration and practical application: 3D modeling technology is an interdisciplinary field of mechanical drawing, computer science, engineering mechanics, and other disciplines. Introducing this technology can promote the integration and exchange of knowledge between different disciplines. In practical engineering projects, 3D modeling technology also has a wide range of applications. By integrating it into the teaching of mechanical drawing courses, students can better understand the connection between theoretical knowledge and practical applications.

(4) 3D modeling technology plays an important role in promoting the teaching of mechanical drawing

courses, which can enhance students' interest and participation in learning, strengthen their practical abilities and innovative thinking, and promote interdisciplinary integration and practical applications. In future teaching, the application of 3D modeling technology in mechanical drawing courses should be further promoted and deepened, providing students with richer and more practical teaching resources, promoting their comprehensive development and future career success.

Disclosure statement

The authors declare no conflict of interest.

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