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Teaching Research of Material Mechanics Aimed at Stimulating Vocational College Students' Interest Based on Simulation Technology

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Abstract: Material Mechanics is an important course for science and engineering students in higher vocational colleges. However, its unfavorable teaching quality has been a problem for a long time. One of the key factors affecting the teaching effect is the students' lack of interest in learning. In order to solve this problem, this paper analyzes the common problems in the teaching of Material Mechanics and applies simulation technology to classroom teaching. The results revealed that with the application of simulation technology, abstract concepts can be displayed visually and vividly, thus making it easier for students to understand. In addition, Mises stress nephograms and animations significantly improve students' learning interest. The teaching method expounded in this paper should be applied to more courses in vocational education.

Keywords: Material Mechanics; Vocational education; Simulation technology; Teaching research; Interest in learning

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1. Introduction

Material Mechanics has been applied to professional fields of civil construction, mechanical engineering, and mineral engineering, and it is one of the important elementary courses in engineering colleges. Since it can be directly used in engineering, the course focuses on applying basic concepts and fundamental theories as well as analyzing and solving actual problems. The learning effect of Material Mechanics will directly affect the learning of other relevant specialized courses, such as the Introduction to Mechanical Design, Metal Cutting, Hydraulic and Air Pressure, Automobile Structure, and Automobile Manufacturing Process. Differing from normal undergraduates, students in vocational colleges have poor learning ability, particularly in theoretical derivation and computing. Integral calculation and derivation are included in many parts of the course, and students are required to understand and master many complex equations. The traditional teaching approach, which is "blackboard-writing + lecturing," is boring. Therefore, students lack interest in learning, thus seriously affecting the teaching quality [1-3].

The rapid development of information technology and digital technology provides technical support to the reform in teaching approaches. For instance, the simulation of finite element technology shows visual animations and stress nephograms so that students may understand abstract concepts. By applying virtual technology to experiment teaching, students will be able to visually appreciate the deformation and evolution rules of materials. While improving students' interest in learning and the teaching quality, this method can effectively reduce the costs [4,5].

On one hand, the traditional teaching approach is unreasonable in many aspects, causing a lack of interest in learning among students; on the other hand, new technologies support the reform of teaching approaches in vocational education. Under such a background, it is significant to systematically sort out the problems in the teaching of Material Mechanics in vocational colleges and propose countermeasures around "teaching with interests."

2. Problems in the teaching of Material Mechanics

2.1. Boring teaching process

Material Mechanics is a subject with high applicability. During teaching, teachers should not only pay attention to imparting theoretical knowledge but also cultivating students' ability to solve engineering problems. In the traditional teaching approach, teachers will explain and display the curriculum contents by writing on the blackboard. Generally, they will explain the fundamental concepts first, followed by relevant equations and their application in typical examples. There are many fundamental concepts in Material Mechanics, in which most of them are abstract and difficult to understand. Students tend to have difficulty in understanding shear stress, couple stress, and stress concentration in textbooks. Most equations in the course require calculus, but students in vocational colleges have poor foundation of mathematics and are easily distracted during the explanation of typical examples. Taking the topic of bending moment as an example, teachers will usually guide the students to carry out complex mathematical operations and draw the corresponding force diagram and moment diagram on the blackboard based on the results, as shown in **Figure 1**. These diagrams are complicated and co-related to mathematical operations, in which an error in any step may affect subsequent links. Therefore, students may be unable to keep pace with the teachers. Teachers have found that many students are unable to follow well in classroom, yet they do not have a better method; thus, this process keeps being repeated. Such a boring teaching process cannot arouse students' interest in learning, and teachers themselves may feel exhausted [6,7].

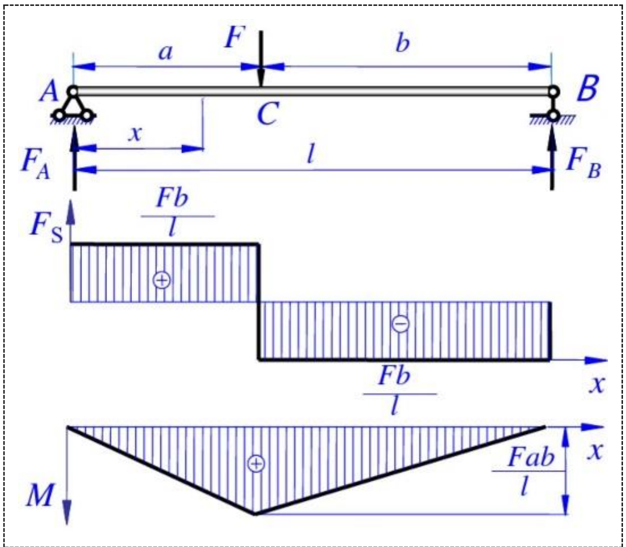

Figure 1. Force diagram and bending moment diagram

2.2. Numerous and abstract teaching contents

The syllabus of Material Mechanics in vocational colleges is usually prepared based on that of universities. The contents are universal and all inclusive, laying more emphasis on theories and systems, while lacking the teaching characteristics of vocational colleges. The emphasis on systematic property and integrity may lead to excessive teaching contents. An academic discussion was carried out with six course instructors of Material Mechanics. They mentioned that the contents of the course are excessive, but the teaching hours are limited; in addition, students lack initiative in learning and complain about high academic pressure. In class, teachers need to spend a lot of time on explaining knowledge about statics and dynamics. The formula derivation of abstract concepts based on calculus, such as inertia moment and polar inertia moment, are particularly difficult for students to grasp. Even if they are able to follow the lesson, it is difficult for them to understand, let alone to apply flexibly. Since the knowledge points are abstract, teachers can only help students to understand by explaining through exercises. With a huge amount of training in problem-solving, the cultivation of students' ability to analyze and solve actual engineering problems is neglected.

2.3. Less emphasis on the laboratory course in Material Mechanics

The laboratory course in Material Mechanics plays two roles: (1) it trains students' experimental skills and helps them master basic knowledge, method, and techniques of experiments in Material Mechanics; (2) it cultivates students' ability of operation and analysis as well as their creative spirit. However, vocational colleges do not pay enough attention to the laboratory course in Material Mechanics, and the proportion of teaching hours is relatively low. In general, experiments are traditional teaching contents centering on verification, in which they are used to verify the correctness and accuracy of certain formulas in the textbook, such as the stress-strain value measurement in torsion test [8-12]. For this reason, students lack the opportunity for independent exploration, as they cannot verify their ideas through experiments. For instance, through the tensile test experiment, students can appreciate that the tensile property of aluminum is inferior to mild steel. However, some students may wonder about the tensile property of composite boards made from aluminum and mild steel. The experimental conditions are ripe, but only a number of teachers provide opportunities for students to conduct exploratory experiments in view of the laboratory management system, the difficulty in reimbursement for specimens, or other reasons. Therefore, the operational ability of students and their creative spirit cannot be trained well, thus affecting their interest in Material Mechanics. Moreover, there is no effective assessment method to evaluate the teaching process, thereby students are forced to finish the task assigned by the teacher during the experiment. After completing the experiment, students tend to "only know how but not why." When facing actual engineering problems and in testing the performance of materials, these students will be bewildered and unable to solve such problems.

3. Exploring teaching approaches

As mentioned above, there are many problems in the teaching of Material Mechanics in vocational colleges, such as excessive contents, boring teaching process, and the lack of emphasis on experiments. These problems directly affect students' interest in learning. The lack of interest and enthusiasm among students will affect the quality of teaching. In order to solve this problem, simulation technology can be applied to teaching.

The finite element software has a very powerful post-processing function, which can be used to display Mises stress nephograms and animations of stress, strain, deformation velocity, and other variables during material deformation [13,14].

Finite element modeling and simulation have been used in classroom teaching, in which Abaqus was used to model, and a large number of Mises stress clouds were simulated. These materials have been applied to teaching experiments and achieved good teaching results. **Figure 2** shows a Mises stress nephogram of the finite element model during necking and fracture of a sample under tension. In **Figure 2**, the Mises stress nephogram is colored to show the difference of stress values at different positions. The more the color tends to blue, the smaller the Mises stress; on the contrary, the more the color tends to red, the greater the Mises stress. Through the demonstration of Mises stress nephograms, students will be able to master the relevant knowledge points of necking and tensile cracking.

The three-point bending experiment of a beam is taken as another case to illustrate. As the experiment is dangerous, teachers prefer not to handover the operation of the experimental equipment (as shown in **Figure 3**) to the students. Usually, teachers will operate the experimental equipment by themselves, while the students stand at a distance to observe. Students will be able to see the bending of the beam sample from a distance; however, it is difficult for students to obtain experimental data, such as the reduction force, stress-strain distribution around the beam, etc. In that case, it will be difficult for students to fully grasp the contents of the bending experiment, let alone use the experiment to further understand other relevant knowledge concepts of beam bending. This is a long-standing teaching problem in vocational colleges. As shown in **Figure 3 (b),** the finite element model can simulate the bending and stress values of samples with different reduction.

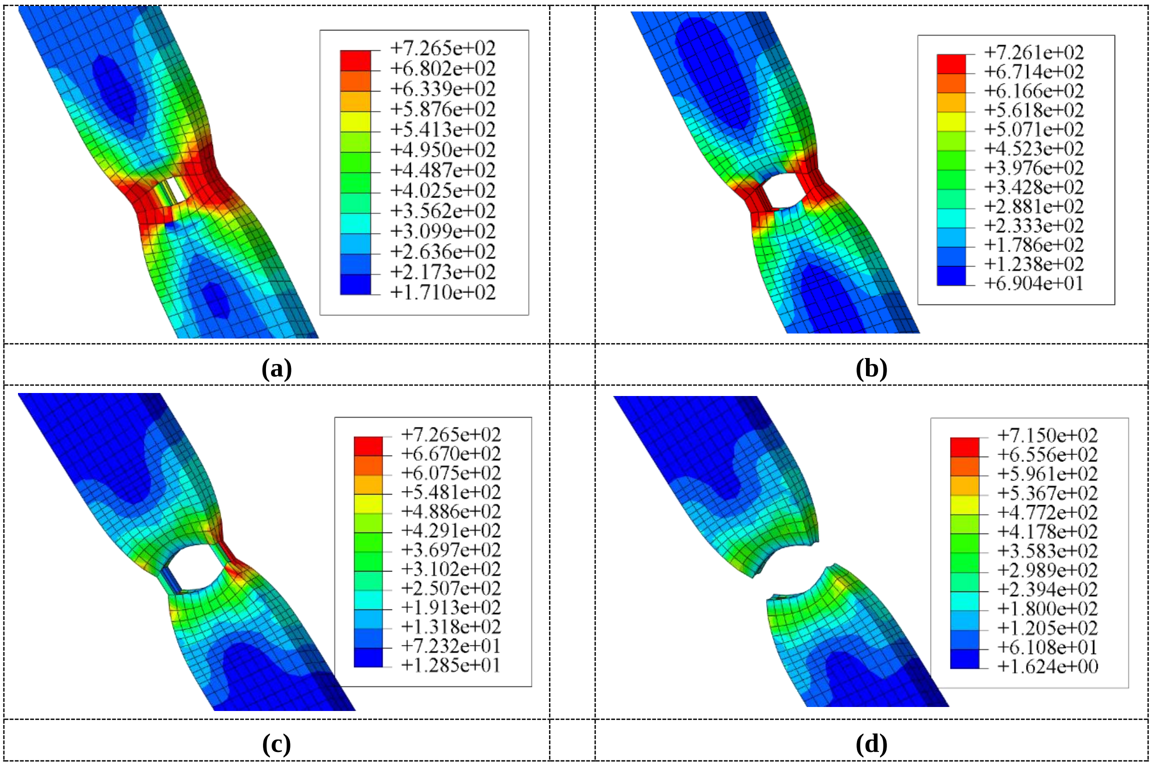

Figure 2. Necking of the finite element model; **(a)** t = 9.75 s; **(b)** t = 11.25 s; **(c)** t = 12.75 s; **(d)** t = 13.5 s

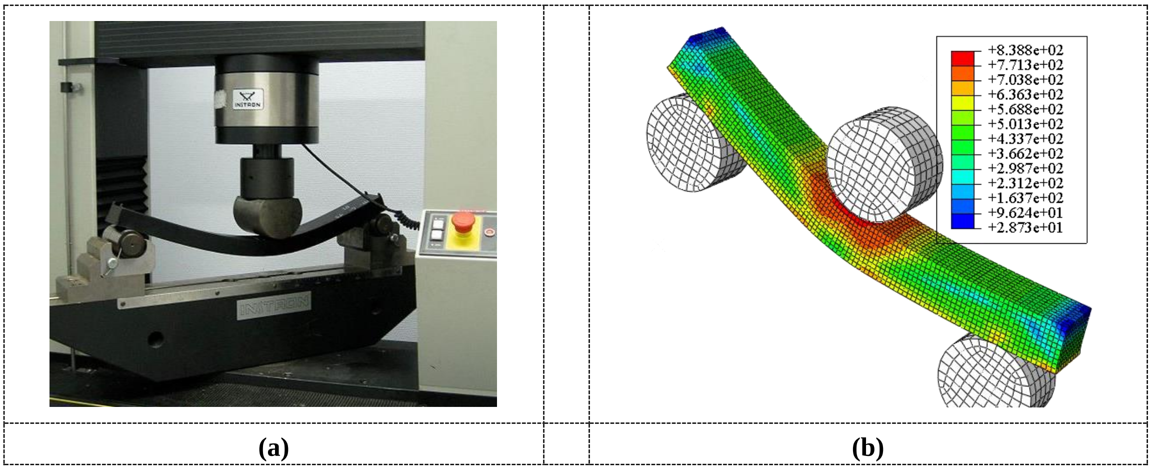

Figure 3. Bending experiment and finite element simulation; **(a)** three point bending experimental equipment; **(b)** results of the finite element simulation

In view of abstract concepts, clear display is one of the advantages of simulation technology in its application to teaching. The Mises stress nephograms of the finite element model show the stress distribution in colors. This method of presentation is clearer and more intuitive than the textbook. The application of these materials has obviously improved students' learning effect and interest. The model simulations are done on a computer, which is not only safe, but also saves the experimental cost. In addition, the knowledge of students can be expanded.

A questionnaire survey was conducted among 30 students. The questions in the questionnaire are as follows:

(1) Q1: Have the materials obtained by finite element simulation enhanced your interest in learning?

(2) Q2: Have the materials obtained by finite element simulation more clearly shown the stress distribution law and deformation process of the beam (or the tensile samples)?

(3) Q3: Does the teaching of modeling broaden your horizons?

The students' votes were sorted and counted. The statistical results are shown in **Figure 4**. As can be seen in **Figure 4**, all the students believe that the application of these materials improves their interest in learning and clearly shows the stress distribution law. Most of the students recognized that the introduction of finite element simulation helped broaden their horizons, but four students disagreed.

In summary, the application of finite element simulation improves students' interest in learning and the teaching quality of Material Mechanics.

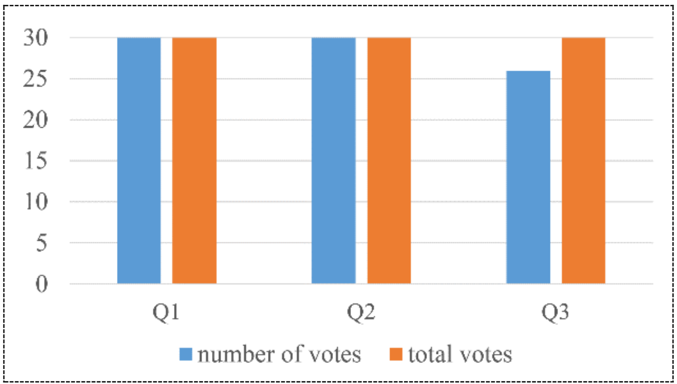

Figure 4. Statistical results from the questionnaire survey

4. Conclusion

In order to improve the teaching quality of Material Mechanics, the common existing problems in the teaching of Material Mechanics have been discussed and two aspects of teaching have been explored in this paper. Simulation technology can be used to form distinct Mises stress nephograms, and with the application of these materials, it is then possible to show abstract concepts visually and vividly, thus improving students' interest in learning and the teaching effect. The Material Mechanics course has numerous contents and abstract knowledge points. Enhancing students' interest in learning is a significant approach to improving the teaching quality. The teaching method expounded in this paper should be applied to more courses in vocational education.

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