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Exploration of Material Mechanics Teaching in Vocational Colleges Based on Engineering Case Introduction

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ABSTRACT
Material Mechanics is an important course for students of science and engineering in higher vocational colleges. However, the unfavourable teaching quality of the course has been a problem for a long time. One key factor affecting the teaching effect is the students' lack of interest in learning. To solve this problem, this paper analyzes the problems existing in the teaching of Material Mechanics, and proposes a method of introducing engineering cases to enhance students' interest in learning. The teaching practice has achieved good results. Students' learning enthusiasm has been strengthened, and the interaction between students and teacher in the classroom has also been improved. The teaching method expounded in this paper should be applied to more courses of vocational education.

Keywords: *Material Mechanics, Teaching, Vocational colleges, Interest in learning, Vocational education.*

1. INTRODUCTION

Material Mechanics is a very important subject for students of science and technology. Material Mechanics is not only a required course for engineering majors such as machinery, automobile and rail transit, but also an important basic of many professional courses. The learning effect of Material Mechanics will directly affect follow-up related professional courses, such as mechanical design, hydraulic and transmission, metal cutting, automobile manufacturing technology [1-3]. Different from common undergraduates, students in vocational colleges have worse learning ability, particularly theoretical derivation and computing ability. A large number of formulas and laws derived from the theory are the most important knowledge points of Material Mechanics. The traditional teaching approach is blackboard-writing and lecturing, which is boring [4-6].

Lack of interest and enthusiasm in learning materials mechanics is a common problem for vocational college students at present. If students' interest cannot be promoted, the quality of classroom teaching cannot be guaranteed. In this context, it is a very meaningful research work to systematically sort out the challenges existing in the teaching of Material Mechanics in Vocational Colleges and put forward targeted countermeasures.

2. ANALYSIS OF REASONS FOR LACK OF INTEREST

2.1. Knowledge is abundant and abstract

In recent decades, China's vocational education has been continuously reformed. One of the purposes of teaching reform is to break the barriers between majors, and to maximize the students' initiative in learning. In order to encourage students to study actively and to provide enough spare time, many schools have generally reduced the total number of class hours [7]. Because of this, the number of class hours of Material Mechanics has been greatly reduced, but the teaching content has not been reduced. Many front-line teachers do not realize the importance of improving students' interest and enthusiasm in learning, but still adopt the original teaching plans and teaching methods. Therefore, the problem of poor teaching quality of Material Mechanics has existed in vocational colleges for a long time. Due to the reduction of the number of class hours, the teachers have to explain the content very quickly in class in order to catch up with the progress. In this way, the lack of

interaction between teachers and students is inevitable, and the classroom teaching effect is poor. After one lesson, the students cannot understand the basic question: what does this formula do? Naturally, it is difficult for the students to get interested and the results is poor. As we all know, the teaching content of Material Mechanics is not only extensive but also abstract, which makes it difficult for students to grasp concepts from the very beginning. For example, force coupling, stress distribution, torsion, moment of inertia, etc. If teachers cannot arouse students' initiative in class, students are easy to be distracted and the effect of the class will be poor. On the one hand, the knowledge points of the course are very abstract and difficult to understand. On the other hand, the number of class hours is reduced and students are not interested in learning. All these factors have seriously affected the teaching of Material Mechanics in vocational colleges at present.

2.2. Experimental teaching facilities are weak

Vocational students prefer experimental and hands-on teaching, and laboratory is an important place to improve students' interest in learning. At present, there is a big gap between vocational colleges and undergraduate colleges and universities in terms of the investment of test-based experimental equipment. For instance, most vocational colleges have only one or two mechanical testing machines. During experimental teaching, teachers usually operate the experimental equipment themselves and let the whole class watch around the equipment. In a class with dozens of students, only the first few students can observe clearly. In addition, because the equipment is generally old, vocational colleges can only complete some simple confirmatory experiments, not comprehensive and design experiments [8-9]. Although some schools have devices for both comprehensive and designed experiments, the requirements of students to do exploratory experiments are often rejected by teachers due to laboratory management system and difficult reimbursement of samples. Therefore, the experimental course of Material Mechanics does not raise students' interest in learning. In addition, because the experimental teaching hours is compressed, students are anxious to finish the tasks assigned. In this way, it is difficult for students to master the purpose and principle of the experiments. They only know how but not why after the experiment. When facing actual problems and it is necessary to test the performance of materials, they cannot cope with it.

2.3. Students are weak in mathematics

Most equations of Material Mechanics needs calculus derivation, while students in vocational colleges have worse foundation of mathematics. The students are easy to be distracted in class. Take the question of bending moment of beam as an example. The instructors led students to carry out complex mathematical operation, and draw corresponding force diagram and moment diagram on the blackboard according to the calculation results, as shown in Figure 1. Those force diagrams and moment diagrams are complicated, and co-related to mathematical operation. The problem-solving steps mainly include 3 steps. Firstly, the constraint reaction forces F_A (kN) and F_B (kN) shoud be calculated according to the external force (as shown in Figure 1). Secondly, the force Q (kN) of cross-section x is calculated. Thirdly, the bending moment M (kNm) of the cross-section x is calculated by the values of all the forces and their corresponding arm values. The special point and function relationship jointly determines the curve morphology as shown in Figure 1.

The error in any step may affect subsequent links. Therefore, students may be unable to keep pace with the instructor before they noticed. Sometimes, the instructors found many students could not follow them in class, and they have no better way but to repeat the process. Such a boring teaching process cannot arouse students' interest in learning.

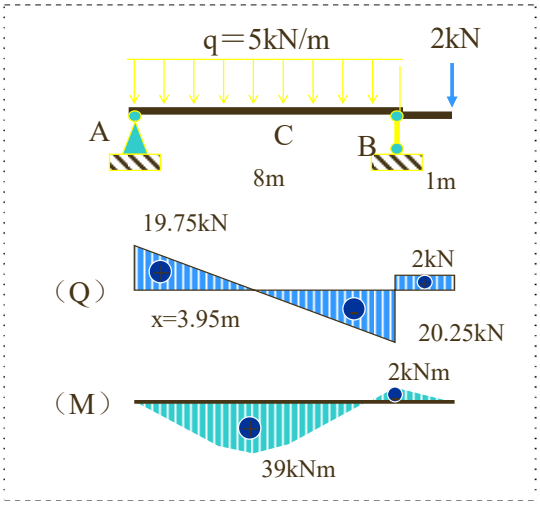

Figure 1 Force diagram and bending moment diagram of a beam.

2.4. Laboratory course in mechanics is given less consideration

The laboratory course in Material Mechanics could play the role in three aspects. Firstly, it could train experimental skills of students, and allow them to master basic knowledge, method and techniques of experiments in Material Mechanics. Secondly, it could cultivate students' ability of operation and analysis, and the creative spirit. Thirdly, the experimental class can enhance students' interest in learning. However, vocational colleges do not pay enough attention to laboratory course in Material Mechanics, and the proportion of teaching hours is relatively low. In general, the experiment in mechanics is a traditional teaching content centering on verification, i.e., the experiment is

used to verify correctness and accuracy of certain formula in the textbook (such as stress/strain value measurement in torsion test). For this reason, students lack the opportunity of independent exploration, and could not verify their ideas through experiment. For instance, through tensile experiment students could find the tensile property of aluminium is inferior to the mild steel. Some students may wonder what the tensile property of composite board made from aluminium and mild steel is. The experimental conditions are ripe, but few instructors take students to conduct experiments for exploration due to laboratory management system, difficult reimbursement for specimen or other reasons. Thus, the ability of operation and creative spirit of students could not be trained well, affecting their interest in Material Mechanics. Moreover, there is no effective assessment method to efficiently evaluate the teaching process of experiment, so that students are forced to finish the mission assigned by instructors during the experiment. They only know how but not why after the experiment. When facing actual engineering problems and it is necessary to test the performance of materials, they will still be bewildered and unable to solve such problems.

3. IMPROVE LEARNING INITIATIVE BASED ON ENGINEERING CASES

3.1. Introduction of typical engineering cases

When introducing an abstract concept, the introduction of typical engineering cases can play an important role. As an example, clips of hitting icebergs and sinking ships in the film “Titanic” can be used as a case when analyzing the brittleness of materials, as shown in Figure 2.

Figure 2 Comparative cases of brittle and plastic materials: Titanic.

By analyzing the mechanical properties of remains of hull steel, experts found that the steel will change from plasticity to brittleness at a very low temperature. In this way, the hull is liable to fracture under small load impact. Because of the brittle fracture, the Titanic sank into the Atlantic with more than 1500 people on board. What a painful lesson it was. The natural introduction of film clips into the teaching content intangibly instills the importance of the course of Material Mechanics in the students. In Material Mechanics, materials with a deformation rate of more than 5% are regarded as plastic materials, such as low carbon steel. The stress-strain curve of low carbon steel is shown in Figure 3.

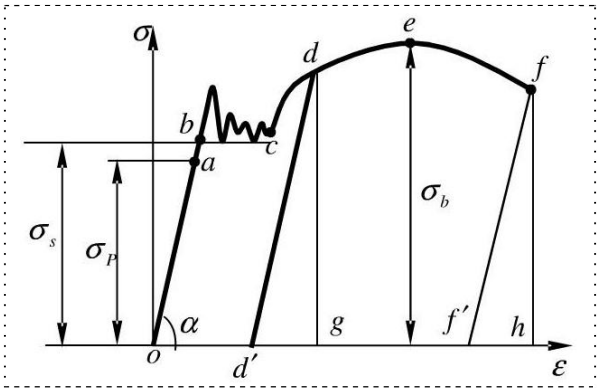

Figure 3 Stress-strain curve of low carbon steel as plastic material.

By contrast, materials with a deformation rate of less than 5% are considered brittle materials (such as glass and ceramics). Scholars have studied the sinking of the Titanic. It is found that due to the large mount of sulfur, the hull steel shows brittleness at low temperature. That is, from the plastic stress-strain law shown in Figure 3 to the brittle stress-strain law shown in Figure 4. Therefore, the Titanic hull can not be deformed in a large scale during impact (similar to the flattening of a pop can), but is directly broken (similar to the falling of a glass).

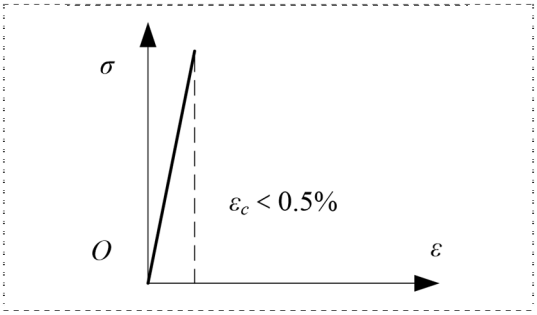

Figure 4 Stress-strain curve of brittle material.

Combined with the film, students can have an in-depth understanding that the deformation resistance of brittle materials is far lower than that of plastic materials. The teacher then asks questions such as whether the impact drill should use brittle materials or brittle materials. Through the students’ answers, knowledge points of brittleness and plasticity are further consolidated.

Further, teachers can guide students to cite cases in life: which items are made of brittle materials and which items are made of plastic materials? Based on students’

answers, teachers can use PowerPoint to show common objects in daily life, as shown in Figure 5 (a) and Figure 5(b), and ask students to explain their material properties (such as elasticity, plasticity, heat transfer) according to their uses.

Figure 5 Plasticity and brittleness of different materials in life: (a) plates are brittle materials; (b) knives and forks are plastic materials.

As another example, the explanation of fatigue failure can be introduced through specific traffic accident cases. On June 3, 1998, a high-speed train in Germany suddenly derailed, killing more than 100 people, as shown in Figure 6.

Figure 6 The 1998 train derailment in Germany.

An investigation later found that the cause of the accident was internal fatigue of the wheels of one of the carriages. Fatigue causes the wheel to break under a small load (far below the limit value). The speed was too fast, which led to the derailment of the whole train and caused serious casualties. The introduction of these engineering cases and safety accidents can immediately attract students' attention, mobilize students' learning initiative, and naturally improve the teaching effect of relevant knowledge points.

In addition, the introduction of similar safety accidents into the classroom can imperceptibly cultivate students' awareness of safety and responsibility. When students enter the workforce, they will be more responsible for designing critical components or checking the safety of materials.

3.2. Complex mathematical derivations are given in homework form

The introduction of typical engineering cases can emphasize the importance of Material Mechanics and enhance students' interest in learning [10-11]. But there is still a teaching problem, and that is taking up valuable class time. Obviously, something needs to be taken out of the classroom. Considering the application of Material Mechanics, this paper presents a solution of assigning mathematical derivation to students in the form of homework.

In order to ensure that students can understand and memorize complex formulas, teachers mainly teach on blackboard during course teaching. Although blackboard teaching is conducive to formula derivation and calculation, it will also lead to slow teaching progress. The mathematical knowledge used in Material Mechanics mainly focuses on vector and calculus. When these contents are involved in teaching, teachers can appropriately combine their basic mathematical knowledge with specific examples in mechanics, and endow the corresponding abstract mathematical quantity with specific mechanical meaning. For example, vectors can be endowed with force, velocity, acceleration and other physical meanings, and thus their related mathematical theoretical operations have visual and referential effects. In addition, calculus and other corresponding content can also be sorted into supplementary materials for the course, printed and sent to students for self-study after class. The teachers can also do a small test for supplementary materials, in which we give extra points to the students with high scores, so as to improve students' enthusiasm and quality of self-study after class. Remember not to cram these supplementary teaching contents into students. Students should be guided to think about the relationship between Material Mechanics and calculus. Calculus is a basic theory (tool) that can assist Material Mechanics in solving practical problems.

To sum up, there are many contents of Material Mechanics, and the concept is abstract and difficult to understand. In addition, the formulas related to mechanics are very complicated, and most of them need the derivation of higher mathematics knowledge. Vocational college students with relatively weak learning ability have difficulty in learning, and lack interest and initiative. When explaining an abstract concept, the introduction of typical engineering cases can effectively attract the attention of students. Improving the classroom

atmosphere and students' interest in learning is the fundamental way to improve the teaching effect of Material Mechanics.

4. CONCLUSION

Vocational education and general education are two different types of education with equal importance. In recent decades, vocational education has provided strong talent and intellectual support for Chinese economic and social development. The improvement of teaching methods and the improvement of teaching quality are the key work of talent training reform in vocational colleges. In order to improve the teaching quality of Material Mechanics, this paper analyzed common problems in teaching of Material Mechanics at present. One key factor affecting the teaching effect is the students' lack of interest in learning. To solve this problem, this paper proposes a method of introducing engineering cases to enhance students' interest in learning. The teaching application has achieved good results. The students' enthusiasm has been improved and the topic interaction is better. Assigning complex mathematical derivations to students in the form of homework, so as to save the class time. The extra homework can add to students' test scores, so they are more motivated to study after class. The teaching method expounded in this paper should be applied to more courses of vocational education.

AUTHORS' CONTRIBUTIONS

Meiqin Liang and Shang Wang contributed significantly to analysis and manuscript preparation. Zhixin Feng helped perform the analysis with constructive discussions.

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