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The Teaching Reform of Engineering Mechanics in Higher Vocational Colleges

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Abstract: Engineering Mechanics is an important subject for science and engineering students in higher vocational colleges. The teaching quality of this course has a direct impact on subsequent professional courses. However, there has been a concern about the poor teaching effect of Engineering Mechanics in higher vocational colleges for a long time. In order to solve the problem and improve the teaching quality, this paper expounds some problems existing in the teaching of Engineering Mechanics in higher vocational colleges and proposes corresponding measures for these problems. Educators need to pay more attention to diversified assessment methods and the application of new technologies. Diversified examination methods can improve students' enthusiasm in learning, while new techniques, such as finite element simulation, generate digital materials, making it easier for students to understand abstract concepts. The suggested measures are worthy of reference and should be applied flexibly in the teaching of Engineering Mechanics.

Keywords: Engineering Mechanics; Teaching reform; Higher vocational colleges; Vocational education

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1. Introduction

Engineering Mechanics has been applied in various engineering fields. It is a basic course in engineering colleges that helps students develop their scientific quality and capacity to innovate. Since it can be directly used in engineering practice, students are required to have strong analytical and problem-solving skills while utilizing basic concepts and theories. The learning effect of Engineering Mechanics will directly affect subsequent professional courses, such as Fundamentals of Mechanical Design, Metal Cutting, Automobile Structure, and Automobile Manufacturing Technology. For a long time, there has been a concern about the poor teaching effect of Engineering Mechanics in higher vocational colleges. Much of the information presented in this course is abstract, obscure, and difficult to comprehend. Teachers are generally under a lot of pressure, and students feel that this subject is extremely tough to understand. It is necessary to pay attention to the issues that arise in the teaching of Engineering Mechanics. For instance, due to the reduction of teaching hours, many students are unable to comprehend the basic concepts, such as force coupling, polar moment of inertia, and moment of inertia. The poor grasp of basic concepts has affected the derivation of formulas and case analysis. Students experience difficulties finishing after-class assignments since the typical cases discussed in class are not well understood. Furthermore, if students have too few hours of experimental sessions, they will not be able to properly exercise their hands-on skills, which will affect their enthusiasm in learning Engineering Mechanics [1-4].

The rapid development of digital technology provides technical support for the reform of teaching content and methods in vocational colleges. For example, finite element technology provides intuitive animations and stress nephograms, making it easier for students to grasp abstract concepts, such as stress concentration, necking, and instability. Meanwhile, the application of virtual simulation technology in experiments allows students to appreciate the deformation and evolution law of materials more intuitively, which not only stimulates their interest to learn and improves teaching quality, but also effectively reduces the costs for experiments [5-8]. In short, although the teaching of Engineering Mechanics in vocational colleges is facing many challenges, new technologies and methods are the impetus for teaching reform.

The pace of vocational education reform cannot be slowed down, and new technologies should be applied extensively in teaching. It is an essential and worthwhile task to analyze the problems existing in the teaching of Engineering Mechanics and put forward corresponding reform plans.

2. Existing problems

It is necessary to systematically explain the challenges faced by Engineering Mechanics in higher vocational colleges. The research team is made up of frontline teachers with years of expertise in the field. They have held extensive discussions on the teaching quality of Engineering Mechanics and discovered four issues.

2.1. Single assessment mode

Examination is the key link in the teaching process. It can objectively and effectively measure the learning effect of students, as well as play a guiding role in the cultivation of students' comprehensive quality. Engineering Mechanics pays attention to cultivating students' practical skills, but its examination mode is still dominated by closed-book examinations; moreover, its examination content focuses on memorizing knowledge points and calculations. This type of examination has an emphasis on knowledge rather than application, and it does not assess whether students can convert engineering problems into mechanical ones, which is not conducive to cultivating their capabilities to solve engineering problems. From the perspective of performance evaluation, the traditional assessment method involves the combination of daily performance and final assessment. Daily performance accounts for 20%, while the final exam accounts for 80%. Students often invest a lot of energy in order to pass the exam; as a result, high scores with mediocre skills are prevalent among students. Some students do not even study during normal days but simply review the content before the exam to prepare for it. As a result, their ability to study independently, analyze, and solve problems, along with their practical skills cannot be effectively exercised. After graduation, these students still do not know how to apply the knowledge learned to deal with practical engineering problems [9-11]. As understood, the core task of vocational education is to cultivate skilled and applied talents. At present, the traditional examination mode is inconsistent with the requirements of talent training.

2.2. Excessive teaching contents that lack the characteristics seen in vocational schools

It is widely recognized that students in vocational schools are less capable of learning than those in undergraduate schools. In regard to Engineering Mechanics in vocational colleges, its syllabus is similar to that of undergraduate colleges. This has a direct impact on its teaching content and methods. The teaching content is too broad, all-encompassing, and theoretical; it lacks the teaching characteristics seen in higher vocational colleges. Although the traditional teaching system is convenient for students to master basic concepts and formulas, excessive emphasis is placed on systematic knowledge and structural integrity. The emphasis on systematicness and integrity will inevitably result in an overabundance of teaching content. Therefore, teachers teaching Engineering Mechanics in vocational colleges are under great pressure to teach at a fast pace. Since the concepts and content of Engineering Mechanics are abstract and uncommon, students are also under great pressure. It is not surprising that students generally lack interest in learning. Other than that, students also lack internship and industrial field research experience, as well as the understanding of the course's purpose and the enthusiasm to learn. The traditional teaching mode focuses on theoretical teaching and rarely includes engineering case studies. In the early stage, the teaching content of Engineering Mechanics is relatively simple, but in the later stage, the content is highly challenging. Many concepts in this course, such as bending of beams, torsion of shafts, and combined deformation of bending and torsion, are difficult to grasp and learned thoroughly. Taking beam bending as an example, most problems are extremely tough to solve, and the explanation process is complicated. Teachers are required to draw stress diagrams and torque diagrams that correspond to the results of mathematical calculations on the blackboard. This has become a challenge for students in higher vocational colleges. If the students are not careful, they will not be able to keep up with the lectures.

2.3. Poor effect of after-class assignments

The practice of doing assignments after class is a way of consolidating and improving what has been learned in class. Homework that is somewhat challenging and may stimulate students' thinking is crucial. These homework assignments may help students further consolidate their knowledge. The after-school assignments based on local Engineering Mechanics textbooks are overly stereotypical, which is far from the real engineering application. The assignments in some textbooks tend to just slightly distort examples or change the data of known examples. These assignments are mainly for students to review formulas. For understanding the knowledge points, they play a very limited role. Another common issue is that the assignments given have very little connection with practical engineering problems. Open assignments that can inspire students' thinking or exercise students' practical skills should be further explored by teachers in higher vocational schools.

2.4. Insufficient attention to experiments

Mechanics experiment is a conventional teaching content based on verification; that is, to verify the authenticity and accuracy of a formula via experiment. At present, the time devoted to mechanics experiments in higher vocational colleges is minimal. In view of this, students lack the opportunity to explore independently, and their ideas cannot be verified through experiments. Some students, for instance, have numerous ideas and would like to be involved in designing mechanical devices, but their petitions for conducting mechanics experiments are frequently denied. The experimental conditions are available, but teachers seldom allow students to conduct experiments for exploration due to the laboratory management system and the difficulty for reimbursement of samples. As a result, students' practical skills and innovative spirit will not be well exercised, and their interest in Engineering Mechanics will also be affected. Another major issue is the absence of appropriate assessment and evaluation methodologies, as well as the difficulty in achieving effective monitoring of the teaching process. As a result, even after experiments, students are only able to understand what is going on, but not why. In the future, students will still be at a loss when faced with practical engineering problems and when required to conduct experimental tests on the properties of materials [12-16].

3. Teaching reform

3.1. Diversified assessment methods

Examinations are the baton of teaching as they play a guiding role in the content and methods used in teaching. The Engineering Mechanics course is considered a discipline with strong practical application. The traditional examination method is based on scores; it fails to pay attention to the cultivation of students' practical application skills. For its course assessment, teachers should pay attention to evaluating students' comprehensive capabilities, and its assessment methods should be diversified. According to the teachers in Conestoga College in Canada, Engineering Mechanics offers a wide range of applications and requires a lot of computations. Therefore, it is impossible to comprehensively and truly assess students' level of learning only through time-limited examinations. In addition, there is a strange psychology of memorizing theorems and predicting test questions before the final examination. As a result of this, students become lazy and lose their enthusiasm for learning. In Conestoga College, the final grade of students majoring in Engineering Mechanics is contributed by four parts: 20% from assignments, 20% from experimental reports, 30% from the mid-term test, and only 30% from the final examination [17]. In addition to the aforementioned four parts, engineering application skills can also be used as a part of the assessment. For instance, in a project that requires students to design a support beam (different cross-section sizes at different positions), the design scheme includes model simplification, stress analysis and calculation, conclusion, etc. After completing their thesis, students will have to present to their teachers using PowerPoint presentations. This kind of assignment can improve students' skills in identifying problems, simplifying them, and applying theoretical knowledge to solve them. At the same time, it helps cultivate their language expression as they exercise this skill. The foreign advanced diversified examination method is worthy of reference for local higher vocational colleges. We can only better address students' learning demands and foster the cultivation of applied talents if we actively explore a variety of assessment approaches.

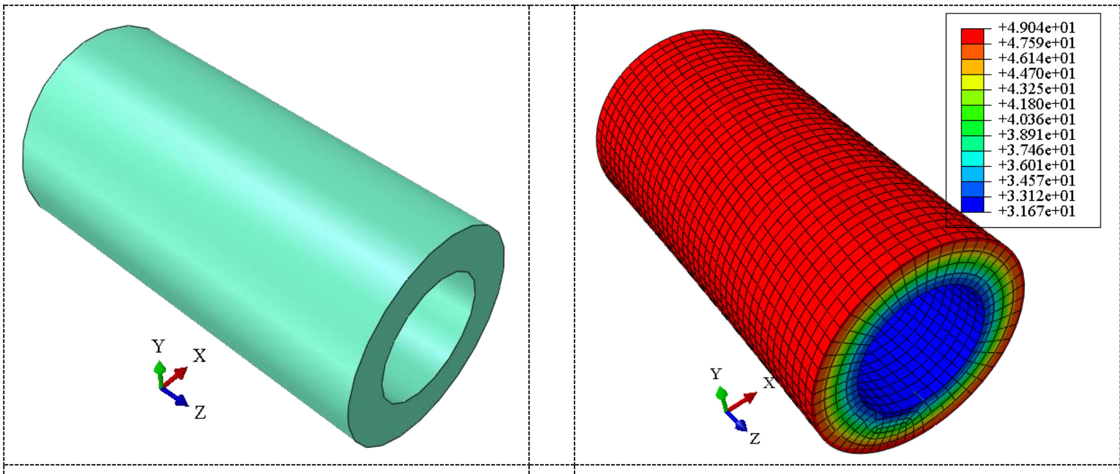
3.2. Apply the finite element software

Many of the contents in Engineering Mechanics are abstract and difficult to understand. For example, the formula of beam bending resistance necessitates extensive calculus derivation. Despite the fact that a lot of time has been spent in class, the students' understanding of the formula remains hazy. Performing experiments is an excellent approach to start. After the completion of the three-point bend test, students can observe the sample, which will be helpful for them to understand the bending resistance of the beam. However, students can only appreciate the deformation of the sample, whereas the stress distribution itself cannot be seen with the naked eye. Finite element simulation technology can solve this issue.

Finite element theory uses the mathematical approximation approach to simulate actual systems (geometry and load conditions). The finite element model discretizes a continuous structure into finite elements and sets finite nodes in each element. In this way, a complex continuum is treated as a collection of elements linked solely at the nodes. The finite element software has a 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 [3, 18-19].

Finite element modeling and simulation has been used in classroom teaching by the research team. ABAQUS software was used, and a large number of Mises stress clouds were simulated. These materials have been applied to teaching experiments and achieved good teaching results.

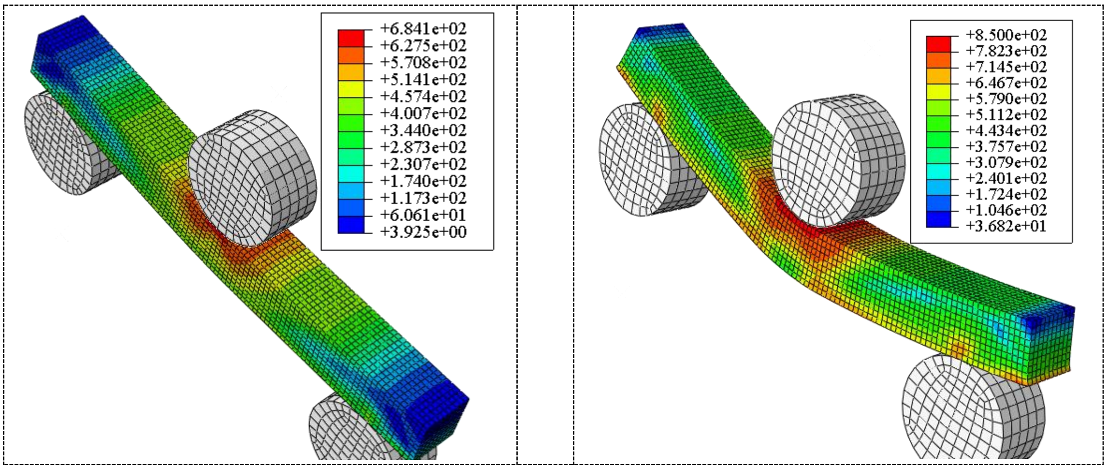
The shaft will deform under torsional external load. Through the study of the theoretical knowledge of the textbook, students can learn that the farther away from the axis, the greater the stress value on the shaft. Therefore, hollow shaft is often used to bear pure torque (such as automobile main transmission shaft) in mechanical design. Students are facing challenges in mastering this test site in depth. **Figure 1** is a finite element model used to simulate torsion. Different colors (the redder the color, the greater the stress) represent different values of Mises stress. Obviously, such a display effect is more intuitive, and easy for students to understand.



(a) **(b)**

Figure 1. Finite element model to simulate torsion; **(a)** finite element model; **(b)** Mises stress nephogram of the model after simulation

Similarly, students with bending resistance of beams also face learning challenges. **Figure 2** is a finite element model used to study beam bending deformation. Different amount of reduction (h value in **Figure 2**), resulting in different deformation and stress distribution. After the finite element simulation calculation, the bending deformation and stress distribution of steel beam are clearly and intuitively displayed. Teaching practice shows that the application of finite element simulation materials improves students' learning interest and teaching quality.



(a) **(b)**

Figure 2. Mises stress nephograms of the model with different reductions; **(a)** h = 2 mm; **(b)** h = 8 mm

3.3. Adopt heuristic teaching

In the course of teaching, teachers should create favorable conditions for active thinking and inspire students to think. Instead of giving extensive lectures, teachers should raise questions on relevant topics that require thinking so as to leave room for students to think. Especially at the end of a class, it is a wise choice for teachers to raise a thinking problem based on the topic taught.

Teachers should also assist students in forming learning groups and reaching correct conclusions via mutual discussion, reasoning, and analysis. As an example, when explaining about shear force and bending moment, the differential relations among bending moment, shear force, and distributed load can be demonstrated, as shown in **Figure 3**. Students can easily come to a conclusion about differential relations if they discuss and analyze the content after class to make tentative reasonings.

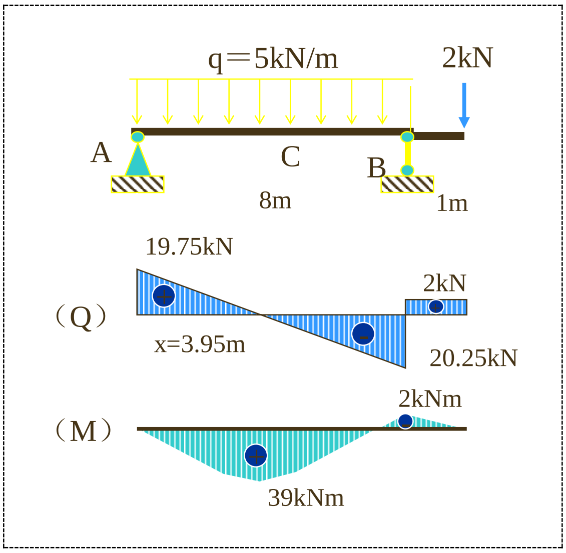


Figure 3. Force and moment diagram

The ability of students to think critically should be acknowledged and commended. Teachers should openly praise them in class or consider awarding them additional credits on the final test. A classroom that actively thinks and answers questions is efficient, and this is also the pursuit of teachers. A simple and effective way is to add credits to the final examination for those who actively participate in class by answering questions.

4. Conclusion

In order to improve the learning effect of students, this paper made an in-depth analysis on the teaching problems existing in vocational colleges and proposed several measures. Diversified examination methods can improve students' enthusiasm in learning. New techniques such as finite element simulation can generate digital materials, which make it easier for students to understand abstract concepts. Frontline teachers can further reflect on the teaching problems raised in this paper and improve their teaching quality. The suggestions provided in this paper are worthy of practice by frontline teachers.

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Disclosure statement

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