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The Current Situation and Teaching Exploration of Engineering Mechanics in Vocational Colleges

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Abstract: Engineering Mechanics is an important basic specialized course, which plays a connecting role in the teaching system. In recent decades, the reform of vocational education has been accelerating, leaving traditional teaching methods far behind. This paper systematically combs challenges existing in the teaching of Engineering Mechanics and puts forward targeted reform measures, among which the introduction of practical engineering cases, construction of online curriculum resources, application of digital visual materials, design of inquiry projects, and other new teaching methods should be given more attention by frontline teachers.

Keywords: Engineering Mechanics; Teaching exploration; Vocational colleges; Vocational education

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1. Introduction

Engineering Mechanics is a required course for majors of Machinery, Transportation, Civil Engineering, Materials, Vehicles, and so on. Through the study of Statics, students can master the basic laws and research methods of particle, particle system, and rigid body mechanical motion, analyze multi-rigid-body motion mechanism, as well as solve system dynamics problems; through the study of Material Mechanics, students can master basic theories and concepts of Material Mechanics by learning calculation methods pertaining to strength, stiffness, and stability of components, as well as analyze relevant mechanical properties of deformed bodies under load [1,2]. Engineering Mechanics is an important basic course, of which the learning effect will directly affect the learning of subsequent professional courses, such as Mechanical Design and Manufacturing, Hydraulic and Transmission, Material Processing, Automobile Manufacturing Technology, etc. With the rapid development of science and technology and the upgrading of industrial production lines, enterprises have put forward ever-growing requirements for talents. In order to cultivate excellent applied professionals, the teaching exploration and reform of Engineering Mechanics in vocational colleges are imminent [3-5].

In the early stage, scholars have made attempts from multimedia application, online teaching assistance, innovative experimental design, and other aspects to improve the teaching quality [4-10]. Although certain effects have been achieved, these studies are aimed at general undergraduate colleges and universities; studies on vocational colleges are minimal in number and are not systematic. It is a meaningful research work to systematically sort out the problems existing in teaching at vocational colleges and put forward targeted countermeasures.

2. Problems in teaching

2.1. Shortening of teaching hours but with large amount of teaching content

China's vocational education has been continuously reformed in recent decades. One of the aims of the reform is to break barriers among majors and maximize students' subjective initiative in learning. In order to guide students to actively learn and provide enough spare time, vocational colleges have reduced the class hours and the number of hours per course. The total hours of teaching in Engineering Mechanics have been shortened, but there is still a large amount of teaching content. Many frontline teachers have not changed their teaching philosophies, nor are they aware of the importance of improving students' subjective initiative; therefore, old teaching plans and traditional teaching methods are still being used. In class, teachers have to teach without stopping in order to catch up with the syllabus. The consequence is that there is little interaction between teachers and students in the classroom, and the teaching effect is poor.

2.2. Poor foundation and enthusiasm for learning

In setting teaching objectives, the teaching competency departments of some vocational colleges directly use the teaching objectives of undergraduate colleges and universities. The issue is that students in vocational colleges have weak foundation in basic courses, such as Mathematics and Physics, as well as weak computing ability, imagination, and sense of space. If teachers do not emphasize on key points or improve their teaching methods in time, it will seriously affect their teaching. Many concepts in Engineering Mechanics, such as force coupling, inertial system, and stress distribution, are relatively abstract and difficult to understand. As a result, students tend to struggle with concepts from the very beginning and face difficulty in absorbing the course content within specified class hours. Although teachers include pictures, videos, and other teaching materials, most students are only able to answer questions, without the ability to transform engineering cases into mechanical models. Abstract knowledge and fast-paced teaching result in the lack of learning motivation and poor enthusiasm for learning.

2.3. Single assessment method and lack of practical assessment

At present, the examination of Engineering Mechanics in most vocational colleges is based on the final examination (written examination), which focuses on memorizing knowledge points and calculations. Although the unified examination can test the students' mastery of basic theoretical knowledge, it cannot test whether the students have the ability to apply theoretical knowledge to engineering practice. This does not only hinder the cultivation of applied professionals, but also go against the construction and development of majors in these schools. Grades at many vocational colleges are assessed in the following way: the usual performance accounts for 20% and the final examination accounts for 80%. This mode of evaluation draws students to spend a lot of energy in dealing with the examination, resulting in students with high scores but with poor skills. Some students do not even study at normal times; instead, they only review before the examination. As a result, their ability to study independently, analyze, and solve problems as well as their practical ability cannot be effectively exercised.

2.4. Backward teaching methods and great pressure on teachers

In order to ensure that students can understand and memorize complex formulas, teachers mainly use the blackboard during course teaching. Although blackboard teaching is conducive to formula derivation and calculation, it results in slow teaching progress. Due to the shortening of class hours, in view of many classroom tasks, teachings are not thorough enough. This further leads to less homework given for after-class completion, which is inadequate to consolidate the teaching content, thus affecting the students' learning effect for the next class. In this way, a vicious cycle is formed. In the past, a survey on the teaching

quality of students in the department of rail transit was conducted. The results showed that if students do not understand the content of two consecutive lectures, it is difficult for them to keep up with the follow-up lesson. In short, frontline teachers generally feel great pressure in teaching; a lot of time and experience have been invested, but the quality of teaching is poor.

2.5. Insufficient experimental facilities and flawed system

Vocational colleges emphasize on technical skills in teaching and applied talents in talent training. There is a huge gap between vocational colleges and undergraduate colleges and universities in terms of the investment in test-based experimental equipment. For instance, most vocational colleges own only one or two mechanical testing equipment. During experimental teaching, teachers usually operate the equipment themselves, while students watch the experiment being carried out. In a class with dozens of students, only a few students can observe clearly. In addition, due to old equipment, only simple confirmatory experiments can be carried out; students do not have the opportunity to participate in comprehensive and design experiments. Although some schools have the equipment for both comprehensive and design experiments, the requirements of students to carry out exploratory experiments are often rejected by teachers due to the laboratory management system and the difficulty in the reimbursement of samples.

3. Teaching reform measures

3.1. Strengthen the teaching of basic knowledge and inspire students to think actively

In view of the problem that students' mathematical foundation is not solid enough, the explanation on key basic knowledge should be strengthened in designing the teaching content. The mathematical knowledge used in Engineering Mechanics mainly focuses on vector and calculus. When these contents are to be included in teaching, teachers should appropriately combine 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 mathematical theoretical operations have visual and referential effects. On the other hand, calculus and other relevant contents can be sorted into supplementary materials for the course. These materials can be printed and distributed to the students for independent learning after class. A small test can also be included in these supplementary materials, in which extra points can be given to students who score high in this test, so as to improve their enthusiasm and the quality of independent learning. However, it is important to remember not to cram students with these supplementary teaching contents. Students should be guided to think about the relationship between Engineering Mechanics and calculus. Calculus is a basic theory (tool) that can assist engineering mechanics in solving practical problems.

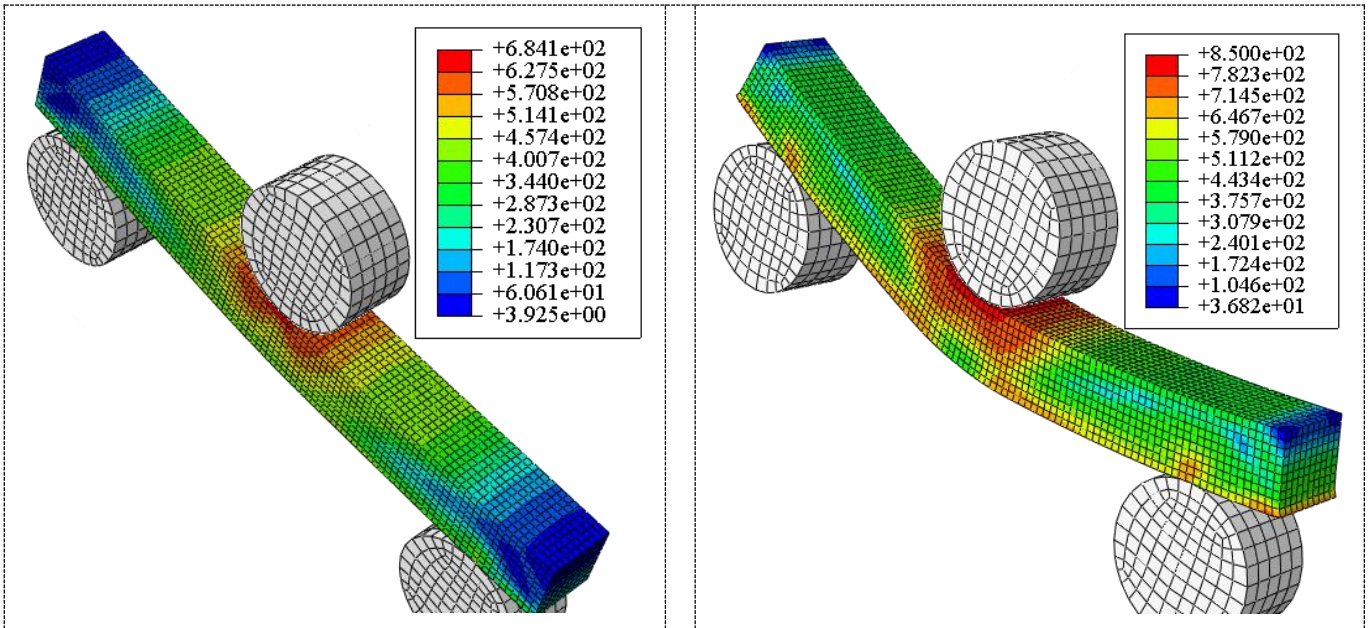
3.2. Pay attention to practical teaching and optimize course content

For students with different majors, foundations, and future professional learning contents, engineering practice can be integrated into classroom teaching, and curriculum content should be optimized in combination with certain majors. The theoretical part of Engineering Mechanics is relatively abstract, and students lack the corresponding practical knowledge of engineering. Therefore, the teaching process should be intuitive, making full use of examples from relevant majors to enhance students' perceptual knowledge, and optimizing the teaching content in combination with other majors. For example, when explaining torsion and torque, teachers can combine them with transmission spindle, which is familiar to students majoring in Automobile Manufacturing. In this way, it does not only lay a foundation for students' future learning of Automobile Manufacturing Technology, but also help them master the theory of mechanics and

virtually improve their initiative. Integrating a large number of similar cases into the teaching of Engineering Mechanics is also helpful for future work. For example, in a situation where an industrial robot in an automobile production line needs technical improvement, which involves certain mechanical calculation (to prevent load overload), it will be easier for students to deal with such a case if they have come across such cases in class.

3.3. Reform the teaching methods based on new technologies

The teaching time using blackboards should be reduced, whereas the teaching time using multimedia should be increased. Multimedia can be used to display deductions of theorems, conclusions, models, and simple formulas, so as to effectively improve classroom efficiency. At the same time, it can be used to display engineering examples, 3D models, animation videos, etc. to improve the visibility in the teaching process, so that students can easily understand theories and memorize information through perception. Finite element simulation technology provides abundant digital resources for Engineering Mechanics. The finite element theory is used to simulate real systems (geometry and load conditions) by using mathematical approximation. 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 connected at the nodes. The finite element software has a powerful post-processing function, which can be used to show Mises stress nephograms and animations of stress, strain, deformation velocity, and other variables during material deformation.



(a) h = 2 mm (b) h = 8 mm

Figure 1. Mises stress nephograms of the model with different reductions

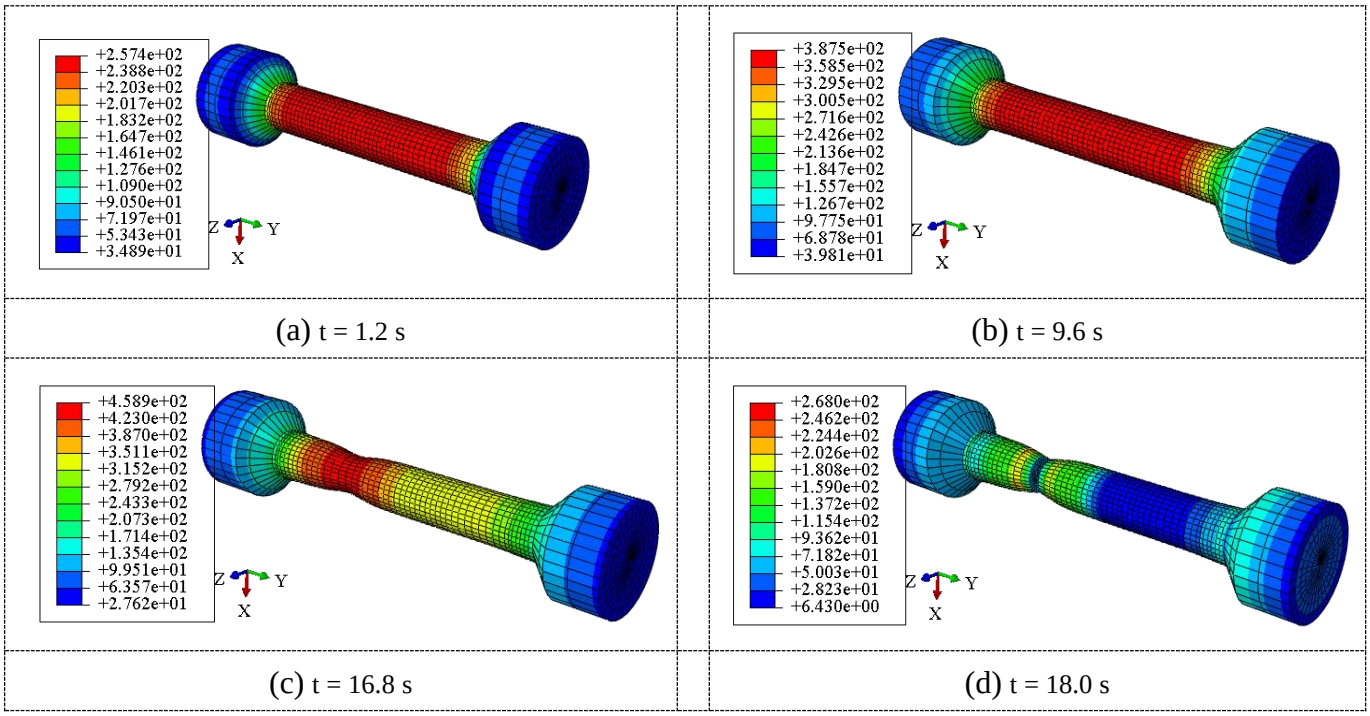


Figure 2. Finite element simulation of tension at different time

Finite element modeling and simulation have been used in classroom teaching. Abaqus software has been used to model, simulating a large number of Mises stress clouds. These materials have been applied to teaching experiments, begetting good teaching results. **Figure 1** is a finite element model used to study beam bending deformation. Different colors represent different values of Mises stress in the model. After the finite element simulation calculation, the bending deformation and stress distribution of the steel beam are displayed clearly and intuitively. Similarly, **Figure 2** is a finite element model used to simulate tension. Obviously, such a display effect is more intuitive and also helps students understand easily. Teaching practice has shown that the application of finite element simulation materials stimulates students' learning interest and improves teaching quality.

3.4. Strengthen classroom management and create a good learning environment

Students in vocational colleges generally suffer from poor learning ability and self-discipline. If classroom management is not up to par, students will tend to play with their mobile phones, watch videos, and so on when the teacher is not looking. First of all, teachers should set firm rules, strengthen discipline management, and create a good learning environment. Second, teachers should try their best to attract the attention of students through various teaching methods, such as introducing mechanical problems relevant to life practice. Third, according to students' cognitive law, teachers should establish reasonable teaching objectives and teaching contents as well as arrange their teaching time. In short, classroom management is a long-term work, which cannot be loosened at any time; grasping students' attention is an approach to creating good learning environment.

4. Conclusion

Engineering Mechanics is an important technical basic course for engineering majors, which is closely related to real life and complementary to the development of engineering technology. The key to its curriculum reform is to accurately locate the problems in teaching and carry out corresponding reform according to specific problems. In class, teachers should improve students' enthusiasm for learning,

cultivate their practical perceptual knowledge, enhance their comprehensive application ability of mechanical knowledge, and provide an effective way for the cultivation of high-quality applied talents. The teaching reform of vocational colleges is a gradual process. Frontline teachers should strengthen the scrutiny of national and school documents, participate in teaching and research activities, learn from the experience of well-known senior teachers, modify their teaching methods in time, optimize teaching plans, utilize typical examples, and make every effort to improve the teaching quality.

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