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Challenges and Countermeasures in the Teaching of Engineering Mechanics in Vocational Colleges

Fei Peng*, Shang Wang, Bowen Chen

School of Automotive Engineering, Beijing Polytechnic, Beijing 100176, China

***Corresponding author:** Fei Peng, pengfei@bpi.edu.cn

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Abstract: Engineering mechanics is as a basic course, and the learning effect of this course directly affects the learning of subsequent professional courses. However, the teaching quality of engineering mechanics in vocational colleges has been subpar for a long time. In this study, we explored the teaching situation of engineering mechanics by using questionnaires, pointing out the challenges faced in the teaching of engineering mechanics and putting forward four targeted suggestions, which include stimulating students' interest and increasing the investment in laboratory equipment, to improve the teaching quality. The findings of this study may provide some reference for the teaching reform of engineering mechanics.

Keywords: Engineering mechanics; Vocational college; Teaching; Countermeasures

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1. Introduction

Engineering mechanics is a compulsory basic course for certain majors, including mechanical engineering, electrical power engineering, rail transport, *etc*. The learning effect of this course will directly affect the learning of subsequent courses, such as mechanical design, mechanical manufacturing, automatic control, hydraulics and transmission, *etc*. [1]. At present, most of the teaching contents of engineering mechanics in vocational colleges and universities are based on those used in undergraduate colleges and universities; hence, they lack certain vocational education characteristics. The abstract concepts and complex formulas in mechanics engineering are the important features in the teaching of this course. Most of the solutions in after-school assignments require students to employ mathematical calculations, which is precisely their weak point [2]. In addition, students often lack internship experience in enterprises and do not understand the dynamics of mechanical equipment, both of which lead to their ignorance of the purpose and importance of learning engineering mechanics. In short, the issue of poor teaching quality in vocational institutions continues to persist. Teachers generally feel that the teaching work is stressful and challenging, while students feel that the course itself is difficult, without much enthusiasm for learning [3].

In order to improve the teaching quality of engineering mechanics, a study was conducted. We first reviewed previous studies and investigated the teaching quality of engineering mechanics through a questionnaire survey. We then analyzed the challenges in the teaching of engineering mechanics. Through our analysis, several targeted suggestions are provided. The findings of this study may provide some reference for the teaching reform and innovation of engineering mechanics in vocational colleges.

2. Research status

The poor teaching quality of engineering mechanics in vocational colleges has been an existing problem,

and much research has been conducted on this subject. Jiao [4] applied the split-Hopkinson pressure bar (SHPB) apparatus to an experimental teaching of engineering mechanics for mining majors. The results showed that the integration of the preamble technology into classroom teaching is feasible and is conducive to improving students' comprehensive quality and innovation ability. Yue [5] proposed a teaching model integrating polymer specialization with engineering mechanics. This teaching model not only helped students understand the relevance of the course and professional knowledge, but also enhanced their learning interest and efficiency. Chen [6] proposed an "online and offline" hybrid teaching model based on the Learning Pass platform in response to the impact of the epidemic on teaching. After reorganizing the teaching content, he conducted a study in actual classroom practice. The results showed that this blended teaching model met the learning needs of different learners and effectively stimulated their interest in learning. Zhao [7] implemented a teaching practice oriented to professional certification. He built a teaching model based on "technology needs" to address the problems faced in teaching engineering mechanics. The study showed that the model was well received by both students and teachers. Su [8] discussed the reform measures of engineering mechanics teaching methods from the perspective of training programs for engineering majors and advocated that these measures could improve students' interest and enthusiasm for learning as well as cultivate their ability to analyze and solve mechanics problems. Zhu [9] pointed out the problems in teaching engineering mechanics through an analysis of the current learning situation and proposed a teaching method oriented to engineering ability with the goal of improving students' comprehensive ability according to the requirements of talent training in the context of "new engineering." This teaching model has been used in experiments with evidence of good outcomes. Yu [10] established an "online and offline" hybrid teaching mode based on the Learning Pass platform from three aspects: guided inquiry before class, feedback and question-answer during class, and extended training after class. He found that this teaching mode not only improves the teaching quality of the engineering mechanics course, but also enhances students' autonomy and enthusiasm for learning. Chen [11] proposed the integration of "character education" into the teaching of engineering mechanics, suggesting that teachers should rely on their own character to influence students, while continuously enriching the teaching content. Lu [12] explored the teaching of engineering mechanics with "problem discussion" as the focus. Through teaching practice, this method has shown to be effective in cultivating students' interest and improving their ability in analyzing problems. Zhang [13] analyzed the requirements for application-oriented professionals in the new era. Taking the concept of strain as an example, he introduced the finite element method in his teaching. The results of the study showed that the students understood the concepts of stress and strain more easily and the teaching effect significantly improved.

3. Teaching quality survey

Drawing on the results of previous researchers, we investigated the teaching of engineering mechanics from five domains: teaching content, teaching style, learning interest, interactive effect, and practical class. A survey was conducted on 71 students from two classes of mechanical engineering major. The questionnaire included five statements.

S1: I am satisfied with the current teaching content.
S2: I am satisfied with the current teaching style.
S3: I am very interested to learn in class.
S4: Classroom interaction has been very effective.
S5: I am satisfied with the proportion of practical classes.

The results of the survey were tallied, as shown in **Table 1**. In general, the students were not satisfied with the current teaching content and teaching style. Only 8 students agreed and strongly agreed with S1, while only 7 students agreed and strongly agreed with S2. Only 6 students (8.45%) agreed with S3, having

the least number of agreeable votes. Comparatively speaking, the effectiveness of classroom interaction received the highest number of agreeable votes, with 27 votes (38.03%). For S5, there were 20 agreeable votes (28.17%). This shows that the proportion of practical classes are not up to the students' expectation. Compared with traditional classroom teaching, practical classes in mechanics can attract students' interest; thus, they should be given more attention. In short, the results of the survey showed that the teaching quality of engineering mechanics is poor, thereby necessitating the exploration of new teaching modes.

Table 1. Teaching quality of engineering mechanics

Statement	Total sample	Strongly agree	Agree	Oppose	Strongly oppose	Invalid
S1	71	5	3	40	21	2
S2	71	3	4	41	20	3
S3	71	0	6	40	23	2
S4	71	8	19	23	18	3
S5	71	5	15	30	19	2

4. Challenges

4.1. Dry and abstract knowledge

The mastery of basic knowledge is the fundamental condition to learn engineering mechanics well. Compared with students in ordinary undergraduate schools, students in vocational colleges are not fond of learning theoretical knowledge and memorizing formulas. Unfortunately, in engineering mechanics, there are plenty of abstract theoretical knowledge and complicated formulas to be learned. Hence, engineering mechanics is often perceived as a difficult course even from the very beginning, and it is common to see students very willingly giving up the course. Taking the concept of stress in mechanics as an example, students tend to have a hard time understanding the concept since stress is intangible. In the examples and questions given by teachers, students are often faced with many knowledge points and formulas that are difficult to understand. This would eventually affect the students' motivation and interest to learn.

4.2. Lack of practical examinations

Compared with ordinary undergraduate institutions, vocational colleges are orientated to supplying skilled talents to the society. Therefore, it is very important for students in vocational colleges to develop their practical skills before stepping into the workforce. Engineering mechanics is a course that focuses on knowledge application. Hence, its assessment should focus on evaluating students' practical ability. With such a focus, students would be able to solve mechanics-related problems when they encounter them in the future. Unfortunately, the examination is still based on written tests, with little emphasis on practical examinations. As a result, students lack the opportunity to perform hands-on experiments and consolidate what they have learned. This will further lead to the lack of motivation and low learning efficiency among students.

5. Targeted suggestions

5.1. Using multiple teaching modes

With the rapid development of technology, multimedia has been adopted by many teachers for lectures. Such lectures aid in revealing certain geometric relations that are difficult to understand. For example, the geometric relationship of circular torsion (deformation diagram) can be clearly shown on PowerPoint (PPT) slides. However, PPT is ineffective when complex formula derivation and calculation are required. In such cases, teachers can opt for the traditional blackboard teaching mode. This mode enables teachers to write

on the blackboard while talking, which may be easier to retain students' attention. In short, teachers should select appropriate teaching modes and consider combining multimedia teaching with blackboard teaching. For more abstract concepts, multimedia can be used as the main teaching mode; however, when it comes to complicated formula derivations, teachers should consider using the blackboard as the main teaching mode with multimedia as a supplement. This organic combination of teaching modes not only improves the efficiency of teaching, but also enlivens the lesson.

5.2. Paying attention to students' calculation skills

As mentioned earlier, engineering mechanics involves many formulas, and many calculations may be needed to solve a difficult problem. If a student does not possess adept calculation skills, he or she may not be able to solve certain problems even if he or she knows the formula by heart. Therefore, it is necessary for teachers to help students review and consolidate basic calculations, including calculus and matrices, in their lessons. It is a seemingly simple, but effective, method to take students step-by-step through the calculation process with a typical example as a case study. It is necessary for students to master some common solution methods. In addition, teachers should consider printing out some common problems and distributing them to the students for self-learning. Students will also be able to exercise their abstract thinking and logical thinking abilities as their calculation skills improve. All these abilities are important for students to learn engineering mechanics and also to solve mechanics problems in their future work.

5.3. Introducing new technologies into the classroom

The rapid development of technology has provided a thrust for educational innovation. New technologies such as "Internet +," modeling simulation, animation production, *etc*. have brought great convenience to the teaching reform of engineering mechanics. Taking finite element simulation as an example, teachers can generate stress cloud diagram and animation through modeling and simulation calculations. These digital materials are very convenient for students to understand abstract concepts, such as stress distribution and stress concentration. The results from the analyses can be used during lessons to increase students' interest and motivation. In addition, students can also consult various materials to modify the models in class, which will also benefit students in developing their self-learning ability.

6. Conclusions

Engineering mechanics is a compulsory basic course for mechanical engineering, electrical power engineering, construction, transportation, metallurgy, and other majors. The learning effect of engineering mechanics will directly affect the learning of subsequent professional courses. At present, the teaching of engineering mechanics in vocational colleges is faced with various challenges. Based on the review of previous research results, four targeted suggestions are proposed. In terms of student training, we suggest to focus on stimulating students' interest in learning and helping them improve their calculation skills. In terms of teaching mode, we propose the combination of multimedia and blackboard, along with the introduction of new technologies into the classroom. The findings of this study may provide some reference for the teaching reform of engineering mechanics.

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Disclosure statement

The authors declare no conflict of interest.

Author contributions

S.W. and F.P. conceived the idea of the study and wrote the first draft of the paper. B.C. revised the format of the article.

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