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Challenges and Suggestions in the Teaching of Mechanics of Materials in Vocational Colleges

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Abstract: Mechanics of Materials is an important basic course, and its teaching quality directly affects the subsequent professional courses, such as mechanical design, mechanical manufacturing, automation, and testing technology. However, the problem of poor teaching quality of Material Mechanics in vocational colleges persists. In this paper, the research of scholars is first described. Then, the research team analyzed the teaching situation and pointed out the current challenges faced in the teaching of Material Mechanics through questionnaires. In order to improve the teaching quality of Mechanics of Materials, this paper puts forward targeted suggestions such as stimulating students' interest and applying new technologies. The findings of this paper can provide reference for the reform of teaching of Mechanics of Materials.

Keywords: Challenges and suggestions; Mechanics of Materials; Teaching; Vocational colleges

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1. Introduction

Most engineering majors, such as mechanical engineering, architecture engineering, and electrical engineering, include a compulsory course called Mechanics of Materials. Mechanics of Materials is an important basic course, and its learning effect will directly affect the learning effect of subsequent courses, such as mechanical design, mechanical manufacturing technology, hydraulics and transmission, automatic control, and many more [1]. The problem of poor teaching quality of Material Mechanics in vocational colleges has existed for a long time. Material of Mechanics consists of many contents, abstract concepts, and complex formulas. The assignments of this course involve many mathematical calculations, which is precisely the weak point of students [2]. In addition, the lack of internship experience in companies leads students to be unaware of the purpose of studying Material Mechanics. Students are not motivated and interested in learning, which leads to poor quality of classroom teaching [3].

In this paper, the studies of the previous scholars are elaborated. Subsequently, the research team analyzed the teaching of Mechanics of Materials in the form of questionnaires. Thirdly, the challenges faced by teaching were identified. Finally, several targeted recommendations are given in this paper.

2. Research status

The quality of Mechanics of Materials teaching in vocational institutions has been lacking for many years. Earlier scholars have conducted much research on different aspects. Liu [4] studied the application of online and offline hybrid teaching of mechanics laboratory courses. He found that hybrid teaching can increase students' independent learning ability and facilitate their personalized development. In addition, this model improves the quality of classroom teaching and solves the problems of traditional laboratory lessons. Zhu

[5] explored the moral education elements of the Material Mechanics course and proposed a targeted teaching design. He found that the integration of moral education elements into the teaching of mechanics courses can fully integrate "teaching" and "educating people". Zhao [6] explored the hybrid teaching reform of the Mechanics of Materials course. Zhao found that this model can increase the time and space for students' learning and is allows a more scientific evaluation of students' learning effects by the teachers. Zhang [7] studied a student-centered stage-based hybrid teaching model using Mechanics of Materials as an example. He suggested three reform measures to be implemented in stages: the first measure is the phasing and gridding of teaching content; the second measure is the integration of multimedia teaching; the third measure is to build a stage-based assessment and evaluation system. Tao [8] explored the construction of experimental class resources of Material Mechanics. He suggested that practical innovation ability can be improved by enhancing the comprehensiveness of mechanics experiments. Scholar Du [9] studied the reform and practice of Mechanics of Materials teaching in the context of new engineering. He argued that the reform of Mechanics of Materials curriculum resources should strengthen the goal orientation and pay attention to the development of heuristic cases. In addition, he suggested that the assessment mode should increase the weight of process assessment so as to strengthen the usual classroom teaching effect. Liu [10] studied the reform and practice of the teaching method of Mechanics of Materials under the outcome-based education (OBE) concept. He believes that OBE teaching method can make students understand relationship between Mechanics of Materials and their majors, thus stimulating their interest in learning. In addition, he believes that it is very important to cultivate students' scientific literacy and research-oriented thinking. Dong [11] applied Ansys software in the teaching of Material Mechanics. The results show that Ansys software can concretize and visualize abstract knowledge, which in turn improves students' learning motivation. The teachers' research ability also improved to some extent in the process of developing Ansys models. Shao *et al.* [12] investigated the application of real-time 3D digital image related methods in teaching Material Mechanics, in which they found that 3D images increases the motivation of students. This mode of teaching, which combines theory and experiment, also helps to enhance students' ability to analyze problems. Zhao [13] carried out a reform of teaching Mechanics of Materials experiments in a hierarchical manner. He suggested the introduction of multimedia technology and virtual simulation into the lessons. In terms of experimental content, he suggested developing comprehensive and design mechanics experiments based on the original verification experiments and establishing a set of hierarchical teaching system.

3. Investigation of teaching quality

Previous scholars have studied the teaching of Mechanics of Materials from five aspects: teaching content, teaching mode, learning interest, classroom interaction, and experiment teaching. We launched a survey on the teaching quality of Mechanics of Materials from these five aspects. The survey was conducted on 2 classes of an automobile manufacturing major with 66 students. The contents of the survey questionnaire are listed below.

Q1: Are you satisfied with the teaching content of Mechanics of Materials?
Q2: Are you satisfied with the teaching style of the teachers?
Q3: Are you interested in Mechanics of Materials?
Q4: I think the interaction of the class is very good.
Q5: The percentage of lab hours is reasonable.

The results of the survey were tallied, and the results of the teaching evaluation were obtained as shown in **Table 1**. Overall, the students were dissatisfied with the current teaching content and mode. The "Agree" votes for Q1 and Q2 were 8 and 9 respectively. The "Agree" votes for interest in learning is the least, with only 5 votes, accounting for 7.58%. In contrast, the effectiveness of classroom interaction received the highest number of "Agree" votes, with 28 votes or 42.42%; this indicates that teachers are

asking more questions in the classroom to improve interactivity. Q5 received 14 “agree” votes, which is 21.21%; this indicates that the number of lab hours falls short of the students’ expectations. Mechanics laboratory classes are more interesting and motivating than traditional classes, and they should be given more attention. In conclusion, the results of the survey show that the teaching Mechanics of Materials is still lacking in many ways, so the exploration of teaching mode is imperative.

Table 1. Investigation on teaching quality of Engineering Mechanics

Question	Total respondents	Strongly agree	Agree	Disagree	Strongly disagree	Invalid votes
Q1	66	1	7	33	21	4
Q2	66	2	7	34	20	3
Q3	66	1	4	35	23	3
Q4	66	10	18	21	14	3
Q5	66	2	12	29	21	2

4. Challenges faced

4.1. Large amount of course content

Mechanics of Materials covers a wide range of content, abstract concepts, and complex formulas. However, the teaching hours are relatively little, causing many teachers to be unable to complete the syllabus while ensuring its quality. As a result, much important knowledge of Mechanics of Materials is explained in insufficient detail, which makes it difficult for many students to understand. Because the classroom knowledge is not firmly grasped, it is challenging for the students to complete the assignments independently after class. The inability to complete the homework independently and the lack of a firm grasp of knowledge will then affect the quality of learning in the next class. This vicious circle causes many students to lose interest in learning and even become bored with learning.

4.2. Lack of practical assessment

Unlike ordinary undergraduate colleges and universities, vocational colleges and universities emphasize the cultivation of skilled talents. Therefore, it is very important to cultivate the practical ability of students in vocational colleges. Mechanics of Materials is a discipline that focuses on knowledge application, so its assessment methods should be focused on practical ability. In this way, students can better apply theoretical knowledge to solve specific mechanical problems. However, the current assessment methods Mechanics of Materials are based on written exams, and practical exams are not emphasized. The examination is the “baton” of education. Under this assessment mode, students generally lack the opportunity to practice their skills. As a result, the students will not have a solid understanding of the course content, which then leads to their learning inefficiency.

4.3. Large amount of mathematical calculations

The teaching content of Mechanics of Materials involves many calculus-based theorems and formulas. The explanation of typical sample questions involves many mathematical calculations, which is the weak point of students in vocational colleges. Teachers need to devote more time to explain formulas or examples in class. Due to the complexity of the calculation process, it is difficult to motivate the students in the classroom. Usually several equations are needed to solve a difficult problem. The frequent inability to complete the after-class assignments independently leads to a further decrease in students’ interest in learning.

5. Targeted recommendations

5.1. Combining multimedia and blackboard teaching

Blackboard teaching and multimedia teaching have their own advantages, and teachers should use them flexibly. Blackboard teaching allows students to see the reasoning process very clearly and immerse into the teaching content very intuitively, and it also keeps the students focused in class. In contrast to blackboard teaching, multimedia teaching makes the teaching convenient, fast, and more efficient. In multimedia teaching, three-dimensional graphics, section diagrams, and animations can be clearly displayed, which helps students understand the content rapidly. Mechanics of Materials has both complex formula derivation and abstract concepts such as stress distribution of beam sections. In order to improve the teaching quality, teachers should combine blackboard teaching with multimedia teaching. For example, when it comes to the derivation of some formulas, the teacher should mainly teach on the blackboard. Similarly, when it comes to some abstract and difficult to understand concepts, the teacher should use multimedia.

5.2. Stimulating students' interest in learning

Interest is a powerful motivation for learning. Interesting and relevant topics can grab the students' attention and stimulate their interest in learning. Teachers should consider the students' interests when preparing the lesson. Using this point of interest as an entry point, teachers should show students an interesting "world of mechanics." Real-life examples of mechanics into the Mechanics of Materials can be introduced in the classroom, so that students understand that the knowledge that they learn is useful, and the examples also allow a deeper understanding of the course content. In short, teachers need to motivate students and develop their interest in learning.

5.3. Increasing classroom interaction

The increasing proportion of multimedia in teaching has led to less and less interaction between teachers and students. The lack of necessary interaction leads to the teacher's inability to grasp the students' learning progress to make necessary adjustments to the teaching schedule and methods. Teachers should ask students more questions in class in order to check their understanding of the topic taught. In addition to student-teacher interactions, there should also be interaction between students like group discussions, cooperative group learning, project-based seminars, and many more.

6. Conclusions

Mechanics of Materials is a very important basic course in vocational colleges and its teaching quality must be highlighted. The learning characteristics of students in vocational colleges should be considered while designing new teaching methods. Based on the results of our analysis and questionnaire statistics, we have identified the challenges faced in the teaching of Mechanics of Materials, and have put forward targeted suggestions such as stimulating students' interest and introducing new technologies in the classroom. The results of this paper provide a reference for the reform of the teaching mode of Mechanics of Materials in vocational colleges.

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Author contributions

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

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