



Research Article

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Teaching Reform of Basic Mechanics Courses in Application-oriented Universities in China

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ABSTRACT

Basic mechanics courses were compulsory basic technical courses for engineering undergraduates from application-oriented universities. In order to improve teaching efficiency and quality of basic mechanics courses for application-oriented universities and meet the needs for innovative persons with high makings in 21 century, aiming at current teaching situation of basic mechanics courses, according to the orientation and training goal of application-oriented universities, teaching reform and practice of basic mechanics courses was studied and discussed in the article from teaching content, teaching method, experiment and practice, testing method and so on respectively.

Key words: Application-oriented universities; Basic mechanics; Teaching reform; Teaching method

INTRODUCTION

Application-oriented universities aim to cultivate high-quality talents with the social adaptability and the competitive power, which play an important role in promoting the popularization of higher education in China. Basic mechanics are compulsory fundamental specialized courses for engineering students, which are vital in the whole curriculum system. Through studying basic mechanics, the students will master the basic knowledge of mechanics, and acquire the abstract thinking ability, the logical thinking ability, and the ability to analyze and solve practical engineering problems, which will lay a solid theoretical foundation for the students to study the follow-up professional courses. In order to make all the students majoring in engineering master the essential mechanics knowledge, and cultivate a new generation of high-level application-orientated engineering talents, how to improve the teaching quality and stimulate the studying interest of the students are urgent problems which need the teachers of basic mechanics to solve.

PROBLEMS EXISTING IN THE TEACHING OF BASIC MECHANICS

Nowadays, the teaching of basic mechanics in application-oriented universities in China generally have the following problems [1-5]:

(1) The teaching content of basic mechanics is old and remains unchanged for many years in application-oriented universities in China, which does not reflect the development of science and technology. The teachers of basic mechanics pay little attention to the introduction of the frontier knowledge of contemporary science, new structures, new materials and new technology to the students.

(2) The teaching method of basic mechanics is single. Many basic mechanics teachers adopt the traditional blackboard-chalk spoonfeeding teaching method. The integrated use of the comparative teaching method, the inductive teaching method, the heuristic teaching method and other teaching methods is relatively rare.

(3) The experimental and practical teaching of basic mechanics is weak. The assigned experimental and practical hours are always few, and more time is allocated to the theory teaching. Experimental and practical time is compressed, which is actually contradictory to the orientation of application-oriented universities.

(4) Computer skills are weak and need to be improved for both teachers and students. Multimedia technology has not been widely used in the teaching of basic mechanics. The students are not accustomed to solve mechanical problems using computers.

(5) The evaluation system of basic mechanics is very single and need to be diversified. For almost all application-oriented universities in China, the evaluation of students' learning effect of basic mechanics is always done by carrying out an examination at the end of the semester.

Based on the above status, the teaching of basic mechanics in China needs to be adjusted and reformed in accordance with the orientation of application-oriented universities, which will cater to the needs of the social development and meet the needs for high-quality innovative talents in the twenty-first century.

TEACHING REFORM OF BASIC MECHANICS COURSES

1. Reform of teaching content

Along with the reform of higher education in China, the teaching hours of basic mechanics have been reduced, which is harmful for all the teachers to achieve good teaching quality. In the limited teaching time, the reform of the teaching content is necessary. The teaching content and the teaching focus of basic mechanics should be reasonably determined according to the characteristics of each major. For example, compression members and bending members are commonly used in civil engineering structures. However, members subjected to torsion are seldom used in civil engineering. So, for the students majoring in civil engineering, the basic deformation of axial tension (compression) and bending should be taken as the teaching focus and allocated more teaching time. Such torsion members as transmission shafts are widely used in mechanical engineering, so the three types of basic deformation of axial tension (compression), bending and torsion deformation are equally important for the students majoring in mechanical engineering.

In order to highlight the orientation of application-oriented universities, the teaching of basic mechanics should weaken the deduction of mechanics formulas, and more attention should be paid to the application of the formulas and the ability cultivation of the students to solve practical engineering problems. At the same time, it will be better if the teachers timely introduce the frontier knowledge of contemporary science, new structures, new materials and new technology to the students in the whole teaching process, which will not only help the students to understand the current situations and the future development trends, but also help to stimulate the learning interest of the students and arouse their initiative.

2. Reform of teaching method

In order to stimulate the initiative, cultivate the active thinking habit and advance the ability for the students in application-oriented universities to solve practical problems, the teaching of basic mechanics should abandon the traditional blackboard-and-chalk cramming indoctrination teaching method, and the comprehensive use of a variety of teaching methods, such as the comparative teaching method, the inductive teaching method, the diagram teaching method, the heuristic teaching method and the multimedia teaching method, should be advocated [6] [7].

The content of basic mechanics is a lot and there are various formulas in the textbook. It is the key to determine the teaching effect of basic mechanics that the students can remember the mechanics formulas accurately. In the teaching process, the teachers should pay attention to the use of the comparative teaching method, and compare and link the similar formulas together to find out the memory tricks which are helpful for the students to remember these formulas. For example, through comparing the stress formulas [8] of the three types of basic deformation of axial tension (compression), torsion and bending, the following rule will be obtained:

$$S = \frac{F}{G} \times D \quad (1)$$

where S , F , G and D represent the stress of each point on the cross section, the internal force on the cross section, the geometric quantity of the cross section, and the stress distribution law, respectively.

Also for example, as shown in Figure 1, based on the equilibrium differential equations [9] of the two-dimension plane problems, the corresponding equations of the three-dimension problems can be easily obtained. At the same time, in order to facilitate the students to remember the equations, Einstein convention should be introduced and the

equilibrium differential equations will be rewritten as below using Einstein convention:

$$\sigma_{ij,i} + f_j = 0 \quad (2)$$

where $\sigma_{ij,i}$ represents the partial derivative of the stress component, and f_j represents the component of the volume force. For a two-dimension plane problem, i and j vary from 1 to 2, and for a three-dimension problem, i and j vary from 1 to 3.

$$\left\{ \begin{array}{l} \frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + f_x = 0 \\ \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \sigma_y}{\partial y} + f_y = 0 \end{array} \right. \xrightarrow{\text{Extending}} \left\{ \begin{array}{l} \frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z} + f_x = 0 \\ \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \sigma_y}{\partial y} + \frac{\partial \tau_{zy}}{\partial z} + f_y = 0 \\ \frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \sigma_z}{\partial z} + f_z = 0 \end{array} \right.$$

Two-dimension problems Three-dimension problems

Fig.1 Extension of equilibrium differential equations

In the teaching process of basic mechanics, the use of the inductive teaching method at the end of each chapter is necessary. The summarization of the concepts and knowledge will help the students to grasp the content of the chapters on the whole. It is also important for the teachers to summarize the problem-solving methods in time, which can greatly improve the students' ability to solve engineering problems. The summarization form of doggerel is the best. For example, the drawing of the cross section shear diagram of the structural members can be summarized as the following rules:

- (1) Draw from left to right;
- (2) At the point of a force, draw directly according to the direction of the force, that is to say, draw upwards if the force is up, and draw downwards if force is down;
- (3) Draw a flat straight line if there is no load on;
- (4) Draw an inclined straight line if there is a uniformly distributed load on, and the inclined direction of the straight line depends on the direction of the uniformly distributed load, that is to say, the straight line will be tilted upwards if the uniformly distributed load is up, and the straight line will be tilted downwards if the uniformly distributed load is down.

In order to cultivate the students' habit of positive thinking in the learning of basic mechanics, and fully mobilize the students' learning enthusiasm and initiative, the heuristic teaching method should be intentionally applied. According to the specific problems, some hierarchical questions should be set up, and the students will be guided to think independently by these questions, which is effective to cultivate the students' ability to analyze and solve problems. At the same time, in the teaching process of basic mechanics, it is important for the teachers to make full use of the multimedia technology and CAI courseware. Multimedia teaching method is more and more important with the development of computer technology and the popularization of network. The comprehensive use of the traditional teaching method and the multimedia teaching method will achieve better teaching effect.

3. Reform of experimental and practical teaching

In order to cater to the demands for the innovative and practical talents, the experimental and practical teaching of basic mechanics should be strengthened, which is also in accordance with the orientation of the application-oriented universities. The theoretical hours and the experimental hours should be reasonably arranged. In the limited teaching hours, the experimental and practical teaching should be carried out as much as possible. Especially, the comprehensive and innovative experiments play an important role in training the students' practical ability and the innovative ability. At the same time, it is important for the teachers to cultivate the students' ability to solve engineering problems using computers.

In order to facilitate the students to carry out the experiments of basic mechanics and make full use of the mechanics laboratory, the daily laboratory opening system is necessary and should be set up, which will allow the students to use their free time to conduct the experiments with their interests and be familiar with the experimental apparatuses.

It will be better if a web-based laboratory system is established. Through the online laboratory system, the students will be able to get to know the experimental items and the experimental equipments in advance. Through making an appointment in the online laboratory system ahead of time, the students can conveniently arrange the experiments according to their own free time.

With the development of computer technology, the basic mechanics experiments can also be simulated by using numerical simulation software, such as ANSYS and ABAQUS, which can simulate the mechanical experiments difficult to carry out under the present experimental conditions. In addition, we should attach importance to cultivating the students' ability to solve mechanical problems by using computers. The students should be demanded to do homework through using mathematical software, such as MATLAB and Mathematica, which will not only help the students to understand the knowledge of basic mechanics, but also help to cultivate the students' ability of practice and innovation.

4. Reform of evaluation system

To achieve good teaching quality of basic mechanics in application-oriented universities, the traditional evaluation system of one-time examination should be abandoned, and a diversified evaluation system is needed. In order to monitor the students' learning situation, it is necessary to hold an examination in the middle of the semester, which can also help the teachers to adjust the teaching process timely based on the examination result. At the same time, in order not to give the students more burden and psychological pressure, it will be better to carry out the open book examination rather than the closed book examination. The evaluation score of basic mechanics in application-oriented universities should consist of the following three parts:

- (1) Score of daily performance which should be reasonably given by synthetically evaluating the students' attendance to the class and their performance in the homework and the class discussions;
- (2) Test score which reflects the students' performance in the two examinations held in the middle and at the end of the semester respectively;
- (3) Experimental and practical score which is the reflection of the students' performance in the practice of basic mechanics.

To achieve the effective assessment of the students' ability and their learning situation of basic mechanics, the proportion of the above three parts of the evaluation score should be assigned reasonably, which is very important in the evaluation system. A recommended proportion of the three parts of the evaluation score of basic mechanics is listed in Table 1.

Table 1. A recommended composition of the evaluation score of basic mechanics

	Daily performance (25 scores)			Examination (60 scores)		Experiment and practice (15 scores)
	Homework	Attendance	Class discussion	Middle of the semester	End of the semester	
Proportion	10%	5%	10%	10%	50%	15%

The test design of basic mechanics in application-oriented universities should be divided into different levels of difficulty, which is prepared not only to test students' mastery of basic knowledge, but also to test students' ability to solve practical engineering problems. Application-oriented universities aim to cultivate qualified engineering talents, so the test design must focus on the investigation on the students' ability to solve practical problems, which is the key to avoid cultivating high-score students with low ability.

The experimental and practical test must be included in the evaluation system of basic mechanics in application-oriented universities. The experimental and practical test of basic mechanics aims to investigate the students' ability to design experimental schemes, and carry out experiments independently using the existing experimental apparatuses according to the given experimental objectives and requirements. The students' experimental and practical test scores are given by evaluating their experimental design schemes, experimental reports and experimental operation synthetically.

CONCLUSION

The teaching reform of basic mechanics in application-oriented universities in China should be carried out innovatively, actively and steadily, which should be based on the specific situation of each application-oriented

university. At the same time, the teaching reform of basic mechanics should be closely combined with the reform and construction of the corresponding other professional courses. In order to achieve better teaching quality and further the reform, the teaching reform of basic mechanics in application-oriented universities needs to be investigated continuously in the aspects of teaching content, teaching methods and evaluation systems.

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