Research and Thinking on Diversified Teaching Methods of Mechanical Theory

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Abstract. The common problems in the teaching process of mechanical theory are found by analyzing the nature of this course. As for improving the enthusiasm of students, the project-driven teaching method, the method of introducing mechanical innovation design into the teaching case, mastery teaching method, the introduction of computer simulation software, and flipped classroom teaching model are studied respectively in order to ensure that students can improve their ability and level of personal knowledge application in the process of active participation and learning practice. It is concluded that these teaching methods can be combined in teaching different chapters of mechanical theory in line with students and situations. It is advocated to strengthen teachers' researches on the course, develop more innovative design cases, software analogue simulation, flipped classroom and other teaching resources so as to obtain better teaching results.

Keywords: Mechanical theory · Teaching methods · Diversity

1 Teaching Characteristics and Problems of Mechanical Theory

1.1 Teaching Characteristics of Mechanical Theory

Mechanical theory is an important professional foundation course which is compulsory in mechanical disciplines of China's universities and colleges to study the principles of mechanical composition, working, design and methods. It is not only a "bridge" course which is closely related to the actual production but also an important stage course for students to learn the innovative ideas and methods of mechanical design. In addition, it has relatively stronger applicability, practicality and engineering. In the process of learning this course, students need to understand the theoretical knowledge of mechanical structure analysis, structural kinematics analysis and kinetic analysis so as to improve their ability of theoretical analysis during learning and practice. If it is analyzed from microscopic perspective, mechanical theory is mainly intended to cultivate the students' ability to design the motion scheme of innovative mechanisms, analyze and study different design purposes and tasks in depth, consider actively different operational coordination and diversified structural operation schemes, and select the best scheme through comprehensive comparison and evaluation. Therefore, it has relatively stronger practicality [1, 2].

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1.2 Common Problems in Teaching Process of Mechanical Theory

At present, the traditional teaching of mechanical theory has the following problems [3].

Firstly, theories are stressed, while practice is neglected. The classroom instruction limits students' understanding of mechanisms to bars, gears, cams or their combination. Take link mechanism as an example. Students see in books only a schematic diagram of the mechanism consisting of straight lines and circles. It is difficult for them to have a good perceptual understanding of real-life mechanical products. Mechanical innovative design, mechanical system transmission, basic scheme conception and design method evaluation, which closely relate subject frontiers to engineering application, should be supplemented and strengthened. And the new achievements, methods and concepts of science and technology related to mechanisms should be closely combined. Attention should be paid to strengthening the ability cultivation in practical application.

Secondly, each chapter is independent individually with few comprehensive theoretical chapters and practical teaching links, and the practice of global design ability of mechanical systems is lacked. It is found in the analysis of students' comprehensive innovation ability that many students face great difficulties and obstacles in the design stage when establishing the motion scheme of mechanical systems. It is difficult to ensure a close connection between theoretical study and practical research and they may even feel overwhelmed.

Thirdly, mechanical theory has little connection with other courses and mechanism analysis is usually made just for mechanism analysis. More comprehensive tasks may be proposed to combine mechanical theory with engineering mechanics and machine design for comprehensive analysis. Or design competition may be used together for connection.

Forthly, the design scheme of mechanical structure proposed in experiments or practice is too simple and students need a large amount of time and energy to complete relevant assignments, so the final teaching quality and results are not guaranteed. In addition, a class is usually assigned the same task, which does not reflect students' difference in personal ability and interest. The link is programmed, which restricts students' innovation ability.

Because of the questions above, the teaching of mechanical theory, which essentially has high innovation, divergent and flexible thinking as well as passionate creation, may become a cramming education with disconnected theory and practice, insipid teaching process, blind learning target, decreased learning enthusiasm and declined teaching quality.

2 Exploration and Thinking on Teaching Methods

In allusion to the teaching problems, teachers of mechanical theory should improve students' enthusiasm and explore diversified teaching methods to ensure that students can improve their ability and level of personal knowledge application in the process of active participation and learning practice, so that students can master the contents and essence of mechanical theory.

2.1 Exploration and Practice of Project-Driven Teaching Method

CDIO project-driven teaching method, led by engineering practice, fully reflects modern educational ideas. It is widely used in western countries with notable results. Practical teaching activities are exercised in this teaching method through a complete "project" task. The knowledge and skills involved in the course are assigned through a specific "project task" to students, who adopt the method of "team learning" and utilize their brains, hands, exchange and cooperation as well as their knowledge and skills according to the task requirements, through five stages of "determining projects, preparing work plans, organizing project implementation, inspection, examine and assessment, summary, appraisal and filing", to complete the project task and present their achievements. In allusion to present educational objectives of engineering education in China, it is recommended to adopt CDIO project-driven teaching method, which is led by problems and projects with "conceive, design, implement, operate" as the key link.

It is the most effective for students to learn in the process of experience and creation. Through project implementation and combination between theory with practice, students will study with questions, which can greatly improve their interest in mechanical theory and manufacturing of mechanical products of science and technology. In the process of manufacturing the product, students will have a clear learning objective, and the fun in the manufacturing process in turn will promote their interest in learning.

2.2 Introducing the Task of Mechanical Innovation Design into Teaching Case [3]

Innovation is the soul of a country. At present, a large number of high-quality all-round talents are needed, especially those with high innovation ability. Innovation points are important indicators in measuring a good mechanical product. The innovation ability of students majoring in mechanisms is often reflected in the innovation point of realizing mechanism functions and structures. Therefore, it not only promotes classroom teaching but also cultivates students' comprehensive ability to introduce mechanical innovative design into the teaching of mechanical theory and create an innovative and pioneering scientific and technological innovation environment.

As for the teaching of mechanical theory, teachers may require students to utilize their extra-curricular time to complete a large assignment implemented as mechanical innovative design project. The large assignment should be scheduled in the first class with specific requirements. For example, a thesis of analyzing and calculating the design scheme of a complete mechanical product must be finished, including function analysis and argumentation, mechanical innovative design and realization, kinetic analysis and calculation, and computer simulation.

The introduction of a multifunctional relief knapsack in the mechanical innovation competition is an example. Figure 1 shows a multifunctional relief knapsack. A detachable four-fold frame structure is proposed in the task. With folded canvas and tent matched tactfully, a knapsack is manufactured, which can not only transport materials but also turn into stretcher and tent. The introduction of this case not only expands

students' innovative thinking but also provides them with knowledge of mechanism design, verifying calculation and computer software modeling [4].

Fig. 1. Teaching case of multifunctional relief knapsack

By introducing mechanical innovative design projects into the teaching of mechanical theory, students become gradually interested in participating in innovative designs, which greatly promotes their learning enthusiasm for mechanical theory and improves their global ability of scientific and technological manufacturing.

An excellent mechanical innovation product is also a favorable material for mechanical theory. The introduction of mechanical innovative design projects into the teaching of mechanical theory is beneficial for improving the teaching results of mechanical theory and students' mechanical innovative design ability. It is worth promoting by teachers of mechanical theory.

2.3 Mastery Teaching Method

Introduction to Mastery Teaching Method. As for mastery teaching method, students need to make full sense of previous concepts before the learning phase of greater difficulty. The opinion is held in this method that all students can master the knowledge without lagging behind or poor performance as long as teaching conditions meet students' demands. This teaching method was proposed more than 100 years ago and its advantages have been verified in the process of teaching. However, it is difficult to implement this method because it needs a large number of hardware resources. Nowadays, the development of cloud computing, Internet of things and big data technology is changing the social ecology and educational ecology. Tremendous

changes will take place to education in future Internet plus environment. It will certainly become an important topic concerned and researched by the educational world to take advantage of mastery teaching method by Internet plus so as to meet the impact of Internet plus on education [5].

Practice Method of Internet Plus Mastery Teaching Method. Learning and perception are usually realized by perception—analysis—integration. At first, a comprehensive and global perception of the teaching content of mechanical theory should be obtained. Then the overall diagram of mechanical theory should be drawn by mind mapping, through which the course is perceived and cognized to know every knowledge point of the course most intuitively and analyze their connection. Finally the whole course system is understood better by course learning.

Mechanical theory studies common issues of the whole mechanical system. It expounds three parts of mechanical motion design, mechanical power design and mechanical system design and introduces other common mechanisms and motion principles. The grammar used in lots of conception description of mechanisms in present textbooks tends to be abstract and theoretical. It is usually difficult for undergraduates with less practical experiences to understand many concepts. And it is harder to connect the object to problems in engineering practice, which results in poor teaching results. Students may have a comprehensive understanding of knowledge points in the course of mechanical theory by mind mapping (e.g. Fig. 2).

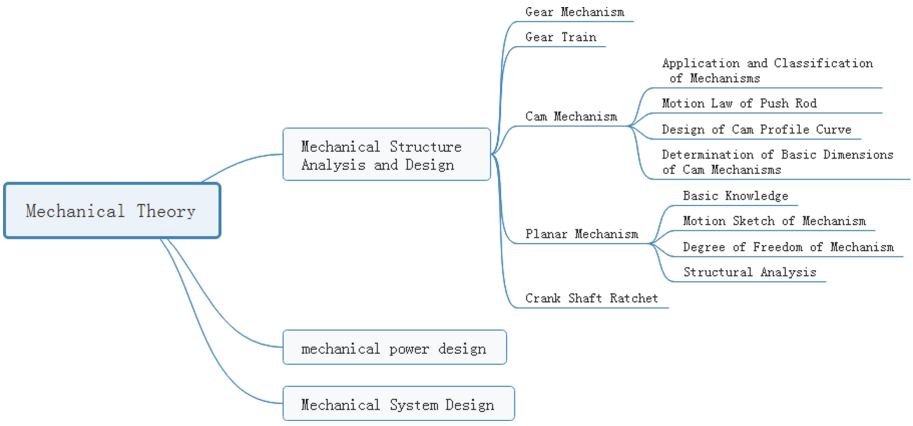

Fig. 2. Mind mapping for the course of mechanical theory

The diagram of knowledge point is about knowledge points derived from the knowledge and concepts of mechanical theory by mind mapping, which embodies radiant thinking. Radiant thinking is a natural way of thinking for human brain. The radiant thinking derived from mind mapping not only accelerates the accumulation of materials but also manages data by hierarchy and category according to their relevancy. Therefore, the storage, management and application of materials are systematized, which greatly improves the efficiency of brain.

As a result, it will improve students' comprehension on the learning of mechanical theory to arrange the knowledge and concepts of mechanical theory by mind mapping and generate a diagram of knowledge point distributed in 3D form.

2.4 Introduction of Computer Simulation Software

With the development of computer technology, CAD and CAE technologies also develop rapidly. Computer-aided instruction (CAI), which uses CAE software, has been widely promoted in various disciplines. Well-known CAE software includes Pro/E, UG and ADAMS, which can all meet the requirements of mechanical theory for aided teaching. For example, ADAMS software can realize D modeling and dynamic simulation for mechanisms in mechanical theory, which eliminates the defects of tedious and difficult operation of graphical method, analytical method and experimental method. In addition, it can not only improve students' learning interest and class performance but also help them with a better understanding and mastery of mechanism motion characteristics [6].

Virtual prototype technology is introduced into the motion analysis and design of mechanisms. Mechanism models are established by ADAMS software. Then motion simulation is used for dynamic display of the motion process of mechanisms. And the results of velocity, acceleration, angular velocity and angular acceleration are output in curves or charts.

Computer simulation technologies can improve students' learning interest. ADAMS software will be learned in the chapter of kinematics analysis, so students can use this software to complete after-class assignments. For example, Fig. 3 shows the model of slider-crank mechanism established by the software. The mechanism has a 200 mm long crank, 400 mm long connecting rod. The slider is a cube whose side is 80 mm. The offset distance is 40 mm and the angular velocity of crank is 10 rad/s. The crank rotates anticlockwise. Figure 4 shows the curves of angular velocity and angular acceleration derived from ADAMS software for the connecting rod.

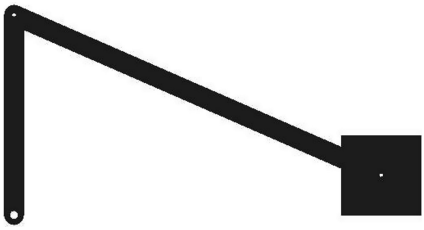

Fig. 3. Model of slider-crank mechanism

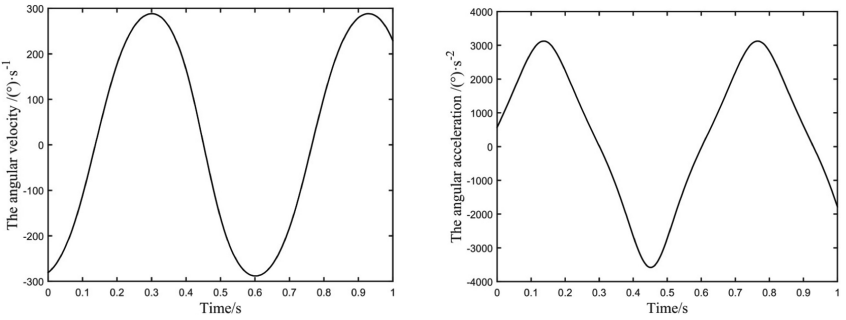

Fig. 4. Curves of angular velocity and angular acceleration of the connecting rod

2.5 Flipped Classroom Teaching Mode [7–9]

Flipped classroom fully reverses the traditional teaching mode of teaching in class and assignment after class. Flipped classroom is a new teaching mode, where teachers provide teaching materials, mainly including micro-videos of teaching, in the information environment and students complete the learning of teaching materials before class. Then teachers and students jointly complete problem solving, cooperation, exploration, interaction and other activities. It fully reverses the traditional teaching mode of teaching in class and assignment after class. Students, receivers listening to teachers passively in the past, become researchers posing problems actively and solving problems with others.

In flipped classroom teaching mode, students complete the learning of course contents independently in advance after class and they participate in learning, discussion and research with prepared questions. Therefore, they will pay attention and their brains will actively deal with problems of themselves and their classmates. And they will try their best to draw their own conclusion. This teaching mode can not only arouse the full enthusiasm of students for learning but also extricate teachers from repeated explanation and demonstration. This teaching mode is particularly appropriate for teaching of applied universities where theory courses are declining.

Flipped classroom teaching mode does not apply to all chapters of mechanical theory. Flipped classroom teaching mode is generally used jointly with traditional teaching modes. For example, it is applicable to the research and practice of “calculation of degree of freedom of plane mechanisms and cautions”, “fundamentals of hinged four-bar linkage” and “design of cam profile curve”. Relevant teaching process can be implemented by teachers’ micro-videos, students’ independent learning and questions, problem solving and posing new problems in class, new problem solving by group discussion, summary and evaluation by teachers and other steps.

3 Summary

It is found in the analysis of nature of mechanical theory and characteristics of teaching methods that diversified teaching methods can be combined to realize diversity of courses, arouse the enthusiasm of students, motivate the interest of students in class, and improve teaching quality and learning outcomes. Therefore, it is advocated to teaching courses in line with students and situations, strengthen teachers' researches on and development of the course, adopt diversified teaching modes so as to design more teaching methods and means and development more teaching materials for relevant chapters, such as design cases, software simulation and flipped classroom, to obtain better teaching results.

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