

The Reform and Practice of "Material Mechanics" Course to Improve Mechanical Problem Solving Ability of Civil Engineering Overseas Students

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Abstract—This paper analyzes the role of Material Mechanics in learning professional course of Civil Engineering students, and analyzes the pressing problem of the Material Mechanics teaching of overseas students in the school. Combined with the need of professional courses related to Civil Engineering, Material Mechanics teaching content of overseas students are discussed. From the different inner needs and personality characteristics of overseas students, the discussion of Material Mechanics teaching mode and teaching method is made. Breaking the traditional teaching framework of Material Mechanics, the problem of students be weary of learning Material Mechanics is solved. Research results have the general reference value to basic course teaching of overseas students of other major of science and technology.

Keywords—civil engineering; overseas students; material mechanics; teaching method

I. INTRODUCTION

Material Mechanics is one of the earliest branches of solid mechanics. It is generally believed that the famous book "the talk and mathematical proof about two new sciences" published by Galileo who is a famous Italian mathematician, astronomer, and natural-scientist in 1638, which marks the beginning of Material Mechanics. The calculation method of mechanical properties and strength of materials is proposed for the first time in the book. Material Mechanics is a very important basic course to Civil Engineering major. Material Mechanics takes solving the strength problem, stiffness problem and stability problem of materials as the general principle, which has strong theory and practice. As a basic course of Civil Engineering majors [1-5], Material Mechanics plays a very important role in the whole course system. Civil Engineering major is a new development in our college. Through the teaching study, students should have the basic concept of engineering component strength, stiffness and stability and computing power, and analysis and calculate the mechanical problem relating to follow-up professional courses by using the basic knowledge of Material Mechanics, which reflects the professional features, for the graduates to better adapt to social development, lay the foundation for work and research in the related. In practice, it is found that civil

engineering students are weak in analyzing and solving practical engineering problems, and the core of these problems is mechanical problems, which indicates that students cannot learn and apply their learning freely. Therefore the teaching reform of Material Mechanics course is very critical. At present, Material Mechanics textbooks edited by Rusan Zhang, Xunfang Sun and Hongwen Liu are selected as the designated teaching book for Civil Engineering majors in domestic colleges and universities, or the textbooks rewritten on the basis of these three Materials Mechanics are selected [6-7]. The classroom teaching methods are basically from the four basic deformations which are the simple stretching (compression), shear, torsion and bending, and then it conclude to the general stress and strain state analysis and strength theory, combined deformation and pressure bar stability problems [8]. After teaching the relevant theoretical knowledge in class, the experimental instructor guides the students to conduct axial stretching, compression, plane bending and other experiments.

In general, the teaching content of Material Mechanics of Civil Engineering major has been relatively stable, with 60-74 class hours and 4-8 experimental class hours and 3.2-4.0 credits [9]. In view of the teaching reform of Material Mechanics, many peers have done research and made some achievements. However a series of problems have been found according to our teaching practice in previous years. As follows, it is not to combine relevant theories in Material Mechanics with practical civil engineering, which leads to students' knowledge being limited to books, and it is difficult to improve their interest in learning. Material Mechanics theory is strong, and concept, formula, calculation, and content are numerous, students accept difficult [10-12]. The development of teaching textbook lags behind the norm.

Our school is the most international university, besides from mainland China, from overseas Chinese, Chinese outside mainland China, Hong Kong, Macao, and Taiwan, the number of this students is more than other school, more than 10000 people, it is the country's first. The objective conditions determined that the basis of overseas students have a certain gap compared with the students from mainland. For the vast majority of overseas students, Material Mechanics is a course which often made them feel very difficult to learn. Material

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Mechanics is an important public basic course in institutions of higher learning, and it is a required course especially to Civil Engineering in our school. As an engaged in the enrollment of Material Mechanics teaching in Civil Engineering professional teachers for years, I deeply realized the teaching method to overseas student lagging behind, it cannot adapt to the needs of the situation, the teaching hours using is unreasonable, textbooks applied is insufficient and so on. Thus it caused the teaching status quo of overseas students is not optimistic. In this paper, starting from the characteristics of overseas students, Material Mechanics teaching method and teaching model of overseas students of Civil Engineering specialty are discussed necessarily. Research results have the general reference value to basic course teaching of overseas students of other major of science and technology.

II. TEACHING INNOVATIONS

In view of the overseas students mathematical knowledge foundation is weak. Poor planning and self-control ability, classroom discipline loose, used to practical application classes, to the mainland teaching concept, methods and means they are not able to accept and so on, the paper puts forward the following teaching mode, teaching method and teaching content reform measures.

A. According to the Training Scheme of Civil Engineering undergraduate Overseas Students, Syllabus is Revised, and Teaching Materials Integrated.

According to the civil engineering professional features flexible teaching content, it is to achieve the organic combination of the Material Mechanics, the related courses, and related content.

Taking the fifth edition of Material Mechanics compiled by Xunfang Sun as an example, we propose the following specific teaching suggestions.

1) Chapter 1: introduction

The main contents include the task and research object of material mechanics, the basic assumption of deformed solids, internal force, section method, the concept of stress, linear strain, shear strain, and the basic form of bar deformation.

2) Chapter 2: axial stretching and compression

The main contents include basic concepts and examples of axial stretching and compression, section method, axial force and axial force diagram, stress on cross section and oblique section of straight bar, maximum shear stress, tensile test of low carbon steel and cast iron and mechanical properties of materials during tensile test, compression test of low carbon steel and cast iron and mechanical properties of materials during compression, allowable stress, strength condition, deformation under axial tension and compression, the concept of stress concentration, and simple statically indeterminate problem of tension and compression.

3) Chapter 3: twists

The main contents include concepts and examples of torsion, torque and torque diagram, stress and deformation of thin-walled cylinder under torsion, pure shear, shear Hooke law, reciprocal theorem of shear stress, stress and deformation of a

circular shaft under torsion, strength and stiffness conditions, concepts and examples of shearing, and practical calculation of shearing and extrusion.

4) Chapter 4: bending internal forces

The main contents include concepts and examples of plane bending, beam calculation diagram, shear force, bending moment and its equation, shear force diagram and bending moment diagram, and the relationship between bending moment, shear force and distributed load concentration and its application.

5) Chapter 5: bending strength

The main contents include formula of normal stress in pure bending, strength calculation of normal bending stress, shear stress of rectangular beam, strength calculation of bending shear stress, and measures to improve bending strength.

6) Chapter 6: bending deformation

The main contents include deflection line of beam and its approximate differential equation, using integral method to find the deflection and angle of the beam, find the deflection and angle of beam according to superposition method, beam stiffness check, and measures to improve bending stiffness.

7) Appendix: geometric properties of plane figures

The main contents include static moment, inertia moment, product of inertia, radius of inertia, parallel displacement axis formula, principal centroid axis, and principal centroid moment of inertia.

8) Chapter 7: stress and strain analysis, strength theory

The main contents include concepts of stress state principal stress and principal plane, stress analysis in plane stress state-analytical method and graphic method, basic concept of three-way stress state, the concept of strength theory, material failure mode, and four common strength theories.

9) Chapter 8: strength calculation under combined deformation

The main contents include concepts and examples of combined deformation, calculation of stress and strength in combination of tensile (compression) and bending, and calculation of stress and strength in combination of torsion and bending.

10) Chapter 9: pressure bar stabilization

The main contents include the concept of elastic equilibrium stability, Euler formula for critical force of slender bar, the influence of different constraints on the rod end and the length coefficient, flexibility of pressure bar, the applicable scope of Euler formula, empirical formula, general diagram of critical stress, stability calculation of pressure bar, and measures to improve the stability of pressure bar.

11) Chapter 13: the energy method

The main contents include calculation of elastic deformation energy of bars, the displacement of beams and simple plane rigid frames is calculated by Mohr theorem and Cartesian theorem, the one statically indeterminate beam and frame are solved by unit load method, displacement of statically determinate trusses with static load method, and functional principle.

B. Overseas Students and Mainland Students Using Dividing Teaching Method

From class 2012, majoring in Civil Engineering has carried out dividing teaching. In view of the difference between overseas students and mainland students, they are divided to different classes for teaching, with different teaching schedule, plan, the difficulty, emphasis and styles adjusted according to the concrete situation. From Material Mechanics perspective, mainland students use more abstract quantitative teaching mode, to do each theorem is derived and the understanding of the demand is higher, and be proficient in the relevant example calculation. Overseas students take concrete standard teaching mode, the demand theory is low, focused on the understanding and application of specific formula. Practice has proved that this mode effect is better.

C. Classroom Teaching Method

1) Attach the importance role of Material Mechanics history to teaching, combine classroom teaching content, properly introduce about Mechanics history knowledge, and increase the Material Mechanics teaching ideology, interesting and scientific.

2) Blackboard writing is given priority to Media assisted teaching method. Material Mechanics classroom teaching should break the previous way of teaching a blackboard and a piece of chalk. Blackboard writing on deriving the Material Mechanics formula and demonstrating problem solving and application plays an important, PPT presentation is irreplaceable. But appropriate uses the multimedia teaching can achieve twice the result with half the effort. The organic combination of blackboard writing teaching and multimedia can make Material Mechanics teaching effect to be better.

3) Students participation in the classroom discussion method. Overseas student active thinking, the characteristic causes its discipline is poorer, but also can be directed at the same time to improve the teaching effect.

Through different questions and exercises in class, stimulate students to think about math problems to enhance consciousness of innovation, and it is the understanding and sublimation of the spoken content. To strengthen overseas students mastery of logical and systematic learning content, can effectively make overseas students from passive to active learning.

4) Strengthen the communication and interaction between teachers and students. Fully communication with students, let students feel the teacher approachable and caring, through in-class and extracurricular communication, it causes the student be parent to teacher, believe to its faith, improve the learning interest.

D. Reform of Teaching Content

Textbook and teaching plans are compiled by taking engineering examples as the main line, and teaching reform is carried out by taking examples around the main line, students can be clear about the use of mechanical knowledge in practical projects, so as to improve students' learning

enthusiasm and the construction of professional knowledge system.

For example, a multilayer frame structure as the engineering main body is analyzed as teaching example, the short column and foundation of building can be used to explain the axial tension and compression knowledge of mechanics, the long bar of building can be used to explain the knowledge of compressive bar stability, the force analysis of primary and secondary beam can be used to explain some knowledge of plane bending, combining with practice it teach the students how to do analysis of practical engineering problems, simplify, solving and design.

E. Grasp the Main Line, Analogy Teaching, and Pay Attention to the Construction of Mechanical Knowledge System

Analogy teaching is to compare the unknown knowledge points with the known knowledge points and find out the same and similarities between them, so that students can not only deepen their memory and understanding of the existing knowledge points, but also make the complex and unknown new knowledge points easy to understand and master, so as to promote students' digestion of knowledge.

F. Theory and Practice Teaching Synchronizing, Highlighting the Application of Knowledge

To cultivate students' application ability, practical teaching is indispensable, so we must pay attention to the cultivation of experimental teaching. Material Mechanics is a course that can be well combined with experiments. Our school changes the traditional teaching method, theory and experiment teaching are synchronized, and it sublimates students' knowledge on books through experiment teaching in time. Experiments are not only demonstrating teaching, but also let students really participate in hands-on practice.

G. Maple Mathematical Operation Software is Introduced

With the wide application of numerical calculation software in engineering calculation, it is necessary for a graduate to master engineering calculation software. The introduction of Maple software in the teaching of Material Mechanics has the following advantages. (a) Maple language modeling is used to solve practical problems, which can shorten the distance between theoretical learning and practical work. (b) It can be done by a computer in a terse program that seems to be usually done by pen. (c) Because of the conciseness of Maple expression, the derivation of formulas and the description of concepts in Material Mechanics can be simplified. (d) Maple's rapid use of three-dimensional graphics, images, and animations to express computational results helps students understand mechanical concepts.

H. The Application of Numerical Simulation Enhances the Attraction of Classroom Teaching

The numerical analysis software ANSYS is introduced to assist classroom teaching, and its powerful modeling and analysis functions are used to demonstrate the deformation process, stress distribution, experimental phenomena and other

processes involved in material mechanics. More importantly, it can make full use of the function of the post-processing module of the finite element software to dynamically display the whole process of the structure from loading to deformation then to destruction, which is equivalent to transferring the mechanical experiment to the classroom at any time, which is convenient, time-saving and economical. Through the simulation of various mechanical behaviors of components by software, the boring mechanical concepts and theories are transformed into vivid pictures with pictures, which can not only improve students' interest in learning, but also enhance their perceptual understanding of engineering practice.

I. Deal with the Relationship between Material Mechanics and Subsequent Courses

For Civil Engineering majors, the course of Material Mechanics is closely connected with many subsequent courses (Structural Mechanics, Steel Structure, etc.). The relationship between structural mechanics and material mechanics is obvious. As for steel structure course characteristics, the calculation formula of design thinking is easy, as long as the related parameter formulas are checked. But these parameters is closely related to Material Mechanics basis, such as mechanical calculation diagram, cross section geometric properties (A, S, I, W), internal force (M, N, Q), and so on. Steel structure design and calculation are based on the premise of these mechanics parameters calculation. The author thinks that as a mechanics teacher of Civil Engineering major, teacher must fully understand the relationship between mechanics course and subsequent courses, and teacher should not stop at the concept and theory of mechanics.

J. Reform of Curriculum Assessment

Under the new talent training mode, it is not enough to reflect the application ability of students only by the results of the final examination paper. The comprehensive ability assessment is implemented through the reform. The course assessment is divided into three parts. The first part is for the usual class and the test of the experiment which accounts for 20%. The second part is the examination result with the mid-term examination 20% and the final examination 30%. The third part is the thesis and dissertation links is to require students according to what they have learned knowledge of Material Mechanics, they write an essay about life application analysis of practical engineering problems, such as they analyze eccentric column of buildings and make mechanical analysis of curved beams, then the students are organized in the classroom to explain and defense, mainly it examines the cultivation of students' application ability, accounting for 30% of the total points.

K. Review Lessons

For basic knowledge and basic principle, through the examples, reflection question, exercises, the mid-term test, reviewing exercises, repeated explain. The final arrangements 2-4 times lesson on reviewing exercises, lead students review the teaching material content.

Students' evaluation in Material Mechanics is getting better and better, and the final course assessment in 2016-2017

Material Mechanics is up to top 1 in School of Mechanics and Construction Engineering.

Practice shows that this kind of teaching model has good effect. Both classes reach the expected target, and the students' classroom performance and later feedback are quite ideal, which win the praise of the overseas students.

III. CONCLUSION

Aiming at the problems existing in the teaching of Material Mechanics in the Civil Engineering major of Jinan University, this paper puts forward some solutions. Combined with the needs of Civil Engineering related courses, the teaching content of Material Mechanics for overseas students is discussed. Based on the different internal needs and personality characteristics of the overseas students, this paper discusses the teaching methods and teaching modes needed by them to learn Material Mechanics. This research has universal reference value to the teaching of teachers who recruit overseas students from other science and engineering majors.

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