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Reform of the Engineering Mechanics Course System

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Abstract

Effective and careful research has been performed by the Section of Mechanics Teaching and Research, Southwest Petroleum University on the content, status, student characteristics of the non-mechanical and non-civil-engineering engineering mechanics course system. Reform ideas and measures, which are also applicable to other common colleges, have been suggested in the course content and course system of engineering mechanics in Southwest Petroleum University. The effectiveness of the reform of the engineering mechanics course system has been validated by actual teaching practice of engineering mechanics in Southwest Petroleum University. Thus, the reform methodology is also applicable to other common colleges.

Keywords

Engineering Mechanics, Course Content, Course System, Reform of Teaching

1. Introduction

A new round of reform in education officially commenced in Southwest Petroleum University in 2009. As a part of the education reform, the project "Reform of Engineering Mechanics Course System for Non-mechanical and Non-Civil Engineering Undergraduates" was also launched. Based on the demand of undergraduate education in common engineering colleges and the university itself, the project team prepared ideas and plans for the reform of engineering mechanics course content according to "Guide to Reform of Basic Mechanics Courses" prepared by "Steering Group of Basic Mechanics Courses" under the Ministry of Education. Engineering mechanics course system saw a comprehensive and systematic reform. A brand-new engineering mechanics course system was established with new teaching modes, echoing courses, and clear yet easy to understand content. Hierarchical teaching programme was also prepared for various requirements of departments for engineering mechanics education.

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Engineering mechanics, which is vastly involved in the university, is an important fundamental technical course for most undergraduates from various engineering departments. It is in the beginning stage of the integration between basic theories and engineering practice and therefore crucial for quality and capability of engineering undergraduates. Theoretical mechanics and material mechanics were the most difficult in the course system reform considering their strict and complete systems and classic content. The reform could not go its own way but had to abide by the following four aspects, i.e. the requirements for engineering mechanics education in the document "Basic Requirements for Engineering Foundation Courses for College Undergraduates" released by the Ministry of Education, the "Guide to Reform of Basic Mechanics Courses" prepared by "Steering Group of Basic Mechanics Courses", as well as the revised specialty catalogue and the document "Principles of Rivising Undergraduate Curriculum in Colleges" released by the Ministry of Education in 1998. In actual reform, however, blossoming and contending of all is encouraged in terms of course system structure as well as re-construction and renewal of course content to create distinct characteristics. Only to meet both of the requirements can the reform of education be examined in teaching and history then finally widely recognized and applied.

2. Reform of Education

Since 2009, the project team had an in-depth investigation of the actual situation and problems in engineering mechanics courses in SWPU and other common colleges with reference to education reform plans of many colleges. The investigation was social and oilfield oriented. The project team carefully studied how to transform education concept and idea to grasp the spiritual essence of education reform. The reform, therefore, properly positioned itself, set objectives, sorted out ideas, and formed characteristics.

No fundamental change will happen to the hierarchy of key and common colleges because talents of contrasts are necessary. The gap between graduates from two types of colleges has been there in terms of basic knowledge, quality, learning ability and so on, so it is with faculty and facilities. The talent development objectives and the target jobs of graduates vary, reform models, surely vary. In terms of the reform of engineering mechanics courses, key colleges focus on hybrid of engineering and science as well as advanced study. Common colleges, however, pay more attention to engineering application and a wider knowledge range. The project team, based on the above mentioned, set the reform position at non-mechanics engineering undergraduates in common colleges. The objective of the reform was to establish a engineering mechanics course system suitable for basic mechanics course for non-mechanics engineering undergraduates in common colleges. The course was a hybrid of public engineering education and student-tailored teaching methods. It could improve students' professional competence, the ability to update the knowledge base via self-study, the ability to analyze and resolve engineering issues with specialties in the world of experience, as well as their awareness of innovation. The basic idea of the reform was going beyond the traditional "theoretical mechanics + material mechanics" engineering mechanics mode to realize a hybrid of relevant fields, set a higher starting point, expand knowledge range, reflect modern research in the field, enhance mechanics modeling and engineering application ability, and emphasize engineering-orientation in engineering colleges. A modularized engineering mechanics course system could be constructed from the perspective of public engineering education and hierarchical teaching. As per actual teaching in common colleges, course content would focus on the expansion of the knowledge base and the improvement of engineering application, with full compliance with course requirements of the Ministry of Education.

The reform of education, in terms of course content, falls into two parts: statics and material mechanics. Achievements in the two parts are as follows.

The theoretical foundation of traditional statics (Section of Mechanics Teaching and Research of Harbin Institute of Technology, 2002) course is statics axiom. The model, which requires long time, focused too much on basic theory but ignores modern engineering issues. The project team, with full compliance with course requirements of the Ministry of Education, moved the focus course content to the expansion of the knowledge base and the improvement of engineering application ability as per actual teaching practice in SWPU and other common colleges. Statics axiom was replaced by the equivalent force principle and equilibrium force system in the statics course (Tao, 2009) to deduce the conclusion of simplified force system and the conditions of equilibrium force system. The approach, with a reduced period, simplified theorem deduction and proving, reduced difficulty, and thus was suitable for common college undergraduates.

Many colleges pioneered in the reform of education in material mechanics. Reform in this course fell into two types. The first type (Song, Wang, & Shi, 1997) did not distinguish basic deformation but mixed internal force, stress, intensity, deformation, and stiffness. The other type (Jiang, 2011) put basic deformation after stress state and theory of strength. Textbooks of the two types were both tested and proved unsatisfactory. The first type split a basic chapter for knowing material mechanics and mastering learning method for material mechanics. Students, under this approach, did not know how to resolve issues in the world of experience with material mechanics theory due to a lack of basic methodology for material mechanics issues in the field of engineering. The second type was, however, against the basic principle of recognition from the shallower to the deeper and from the easier to the advanced. In common colleges, students found it hard to proceed. Considering the two unsuccessful attempts, the traditional model (Tao, Huang, & Lin, 2011) was adopted for material mechanics in SWPU. Material mechanics theory was based on the basic deformation and then proceeded to combine deformation in a from the easier to the advanced way. In actual teaching, the course content of material mechanics was modified as per years of teaching experience. The chapter of section geometry was in the appendix for self-study, after torsional deformation, or in the chapter of bending stress. As per our teaching experience, this chapter was indispensable for common college students. Self-study, for most students, was not enough. If in the chapter of bending stress, students could not fully understand it. If after the chapter of tensional deformation, students would forget about material mechanics in the chapter of bending stress. In the reform, the chapter of material mechanics was after the chapter of bending internal force. Therefore, students had a deeper understanding of section geometry thanks to the immediate application of what learnt. In the chapter of stress state and intensity theory, traditional textbooks spent a long period to respectively introduce analytical method and the graphical method. This was against the actual teaching situation. The two methods were mixed with emphasis of analytical method ideas as well as introduction to the perceptual intuition and convenience of the graphical method. Students had a better understanding of the stress state in a shorter period. The above mentioned were only two aspects of the reform of education. More reform details were represented in textbooks, the mechanics modeling for engineering issues, the development of practical ability for students (Wang, 2011; Lin, 2011), and clear yet easy to understand course content.

3. Teaching Practice

Through study and discussion to transform education concept and idea, the project team set the guiding ideology and basic principles for the reform of education and was ideologically ready for the reform. After thorough investigation, the project team prepared concepts and objectives for the reform of engineering mechanics course system for non-mechnical and non-civil-engineering undergraduates and also suggested a basic framework for the reform of engineering mechanics course system for non-mechanics engineering undergraduates from common colleges.

The reform of the engineering mechanics course system for non-mechanical and non-civil-engineering undergraduates commenced in 2009. Based on thorough investigation, the project team discussed the reform plan and prepared the teaching programme. Engineering mechanics course in SWPU fell into two layers, the 80-period course for oil-gas storage and transportation, material sciences etc. and the 64-period course for measurement and control technology, security engineering etc. Teaching programmes "Engineering Mechanics 1" and "Engineering Mechanics 2" were respectively prepared as per different requirements. The project team then organized preparation of the in-house textbook Engineering Mechanics for "Reform of Engineering Mechanics Course System for Non-Mechanical and Non-Civil-Engineering Undergraduates". After a period of teaching experiment with effects, the project team discussed the revision of the textbook, sent the textbook for review, and finally provided the textbook draft to be officially published to publishing house.

Four rounds of teaching experiments happened in two years as shown in **Table 1**. Through teaching experiments, the project team adjusted basic concepts, polished in-house textbooks, and prepared for the official publication of the textbook. The experimental textbook Engineering Mechanics (Tao, Huang, & Wang, 2011) was published by Science Publishing House in August 2011, reflecting phase results of "Reform of Engineering Mechanics Course System for Non-mechanical and Non-Civil Engineering Undergraduates". The textbook was awarded Class 3 Award of University Level Excellent Textbook of SWPU in 2010 and Class 1 Award of University Level Excellent Textbook of SWPU in 2012. Project "Reform of Engineering Mechanics Course System for Non-mechanical and Non-Civil Engineering Undergraduates" was awarded Class 2 Award of Oustanding Teaching Achievement of SWPU in 2012.

Table 1. Four rounds of teaching experiments.

rounds	time	class	majors
1	Autumn semester of 2009-2010	2008	Oil-Gas Storage and Transportation
2	Spring semester of 2010-2011	2008	M&C Technology, Automation, Electric Automisation
3	Autumn semester of 2010-2011	2009	Oil-Gas Storage and Transportation, Material Sciences
4	Spring semester of 2011-2012	2009	M&C Technology, Automation, Electric Atomisation

4. Quality and Value of Reform

Our reform findings are of great promotional value. The guiding thoughts, basic concepts, and measures can be a reference to other common engineering colleges. The teaching programmes have been listed in the teaching plans of relevant departments. The experimental textbook Engineering Mechanics, as a basic mechanics textbook prepared by teachers from a common college and for common college students, is of clear orientation (connecting the past and future, focus on engineering undergraduates in common colleges) and innovative system (re-organizing course content based on basic research methodology for engineering mechanics as the main line, having hybrid, renewal and expansion of theoretical mechanics and material mechanics). The textbook focuses on the development of ability in mechanics modeling and basic research methodology. With its distinct engineering features, the textbook can meet teaching requirements of not only undergraduate engineering courses in common colleges but also undergraduate engineering courses in a few key college departments. The textbook has been adopted in relevant departments with good results. The failure rate of engineering mechanics in the whole school is reduced by about 5 percent, the mechanics competition results steadily improved while our school participated in, and we won the first prize in the Sichuan Provincial mechanics competition many times.

5. Conclusion

The system of static course can not only save time, but also reduce the difficulty of teaching, which is based on the equivalent force principle and equilibrium force system. The guiding thoughts, basic concepts, and measures can be a reference to other common engineering colleges.

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