

Exploration and Practice of Inquiry-based Small-Class Teaching Mode for Ability Training

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Abstract- Inquiry-based small-class teaching mode is to reduce the number of students and designs discussions among groups in the teaching procedure. In the discussions, students need to survey literatures, discuss with the partners, argue and defend his/her views, accurately analyze and calculate, and present his/her group outcomes etc. The whole process can make students do efforts to find useful information, pay attention on teamwork, defend themselves views, communication, academic thinking, presentation etc. And all the students focus on the contents of class due to small number of students. It also can improve the learning efficiency and develop student's competent abilities. The new teaching mode was practiced in industrial engineering major for one semester. As a result of the findings, the inquiry-based small-class teaching mode is an effective tool to improve the learning efficiency and competent abilities of students. In addition, this training meets the requirements of education of engineering.

Keywords-inquiry-based, small-class, teaching mode, ability training

I. INTRODUCTION

The common problems of engineering courses under the traditional teaching mode are as follows: 1) the more theoretical knowledge which is not closely integrated with the practice are introduced in the classroom, and the theory is seriously disjointed from the practice; 2) the experiment is sequencing which means that students do the experiment following the designed steps, and the function of practice is not obvious; 3) the case study of courses is missing or programmed in the practice section; 4) the examination mode is mainly closed-book examination with specific knowledge points for checking students master the professional knowledge or not, so that students can form a situation of rote memorization before the examination and quickly forget after the examination [1-2].

The traditional teaching modes focus on the giving of specific knowledge and technology. Under this training mode, students will find that the knowledge they have learned is far from the ability they need in their practical work. This is also the problem that many students generally propose at present that what they have study are not use.

However, according to the Accreditation Board for Engineering and Technology (ABET) [3], there is no requirement of graduation for mastering specific knowledge and skills. But all the requirements are for cultivating ability.

This is contrary to the traditional teaching mode mentioned above. And professor Spady [4] proposed that functional role ability and high-level general competence are the key goals of education.

In the study of professor Spady, fulfilling role competence, high-level general competence and specific knowledge and technology are the three objectives of training students (Outcomes of education). The levels of these three objectives are gradually decreasing. The first goal is to cultivate students' ability to fulfill their roles after they start work. That is to say, students should possess the abilities required by their jobs when they come to their actual jobs. The second goal is high-level general competence, which refers to critical thinking, creativity and innovation, communication and language skills, global vision, leadership and teamwork, entrepreneurship, cultural appreciation, lifelong learning ability, etc. [4]. The third goal is to give specific knowledge and technology which are demand mastered in the traditional teaching. The first two goals are ability cultivation, and the last one is the foundation to support the first two goals. From the point of view of training students, it is obvious that the first two goals are more important than the third one in mastering specific knowledge and skills.

It is easy to find that first two goals of professor Spady meet the requirements of the Accreditation Board for Engineering and Technology (ABET). The third goal is what the traditional teaching is doing. The response from students show that third goal (outcomes of education) is not what the student want get from university.

Therefore, it is necessary to design the training of students' abilities in all aspects of the course in accordance with the requirement of ABET and the goal of training students' abilities, so as to carry out an all-round reform of the courses involved.

In this paper, taking the basic course of mechanical design as case study, the teaching contents and assessment methods of this course have been comprehensively reformed following the new reformed teaching mode. And the new teaching mode is implemented and results are analyzed. The organization of this paper as follows: The reform mode of course is presented in section II; Operation and implementation are introduced in section III; Results and analysis are shown in section IV; At the conclusion is given in section V.

II. INQUIRY-BASED SMALL-CLASS TEACHING MODE

Based on the introduction above, the comprehensive reform will relate to many aspects, for example, class size and time of teaching, re-organizing content of course, inquiry-based discussion, case study, homework, lab work and assessment. These seven aspects will be explaining separately below.

A. *Reducing Class Size and Time for Teaching*

In generally, for the professional course, the number of students is normally over 60 students, even over 100 students in some universities. Some students in last several rows cannot focus on or follow what the teacher said for big size class. The teacher has not enough time and energy to pay attention every student. In order to improve the learning efficiency and effect of class, it is necessary to reduce the class size. The number of students in the class is reduced to 30 around. The small-class makes more students focus on the learning.

During teaching section, to traditional teaching mode, the teacher presents and explains all the knowledge which are specified in the class. This mode makes the teacher very tired. The teacher complains that he or she has not enough time to give all the knowledge what should be given in the class. On the contrary, the students just are interested in what will be on the exam paper. And students quickly forget what they study after the examination. So, in this new teaching mode, it reduces the time when the teacher uses to give the knowledge in the class. It takes time of teacher in class to students. Inquiry-based discussions are designed in the teaching procedure. The students should study by themselves knowledge used in discussions. The organizing detailed content of lecture will be explained in section B. The inquiry-based discussion will be detailed explained in section C.

B. *Re-organizing the Content of Lecture*

For the contents that should be given in the classroom, the contents are arranged and organized again according to the logical relationship between them. For example, mechanical engineering design course, breaking the previous introducing each mechanical elements (gears, bolted joints, belts, bearings, etc.), some knowledge points that are relatively important and suitable for discussion will be used in the form of inquiry-based discussions and case studies. This mode can make students learn by themselves. The teacher's teaching hours are reduced from 48 hours to 26 hours. This mode avoids that the teacher introduces all the knowledge in the classroom. And students obtain more knowledge than traditional teaching mode. And content of lecture is more systematic and reasonable.

C. *Inquiry-based Discussion*

Inquiry-based discussion is a new and important content in this reform. According to the order of knowledge points,

each time for the knowledge points to be studied, the real mechanical structure or equipment containing the knowledge points to be studied is designed as a topic of inquiry-based discussion. These topics come from many sources, such as foreign original textbooks, Chinese textbooks, practical engineering simplification examples or the mechanical institutions or equipment that students are interested in. These sources ensure the diversity of the topics. For example, in the course of the mechanical engineering design, because the calculation of transmission ratio of gear train is based on the knowledge of fixed transmission ratio, after the lecture on the fixed transmission ratio of gear in class, the students are asked to analyze and calculate the real examples of gear train in an inquiry-based discussion, instead of the previous mode that teaching knowledge points of gear train in the class. And students are asked to do presentation to explain the calculation of transmission ratio for gear train. For such a topic, students need to use the network, textbooks, manuals and other materials to discuss each other in groups, especially the use of teaching content for the main analysis. Each group then presents its own analysis the process and the results. And each time the student who makes the presentation is different, so that each student has opportunity to do oral expression exercise. Finally, the scores of inquiry-based discussion depend on the analysis, accurate and the manuscript on site. In addition, the attitude of each discussion, the close degree of teamwork, the perfection and correctness of the results, and the quality of manuscripts are used as the evaluation criteria for inquiry-based discussions. At the same time, peer evaluation (students) is also considered.

The students can obtain multi-faceted ability after inquiry-based discussion training: Such as lifelong learning ability, communication skills, critical thinking, problem solving skills, teamwork spirit, ability to access information, the ability to use modern tools and so on.

D. *Case Study*

Case study is another new part of the reform. At the end of the course, students are required to consult the latest mechanical products, analyze their principles and functions with the contents of the course, or design a mechanism or product by themselves, and elaborate the principles and design process with the contents of the course. The purpose is to enable students to analyze and design a real mechanical structure or mechanism by themselves, so as to understand the design process and manufacturing process of machinery. Students can make use of the network, textbooks, related books, known engineers and so on. The content of analysis should be related to the course content, such as connection, degree of freedom analysis, modeling, statics analysis, assembly, tolerance, manufacturing and so on. It is necessary to write about 20 pages of report, which includes: cover page, abstract, introduction (history, introduction, frontier, problem), analysis process, result analysis (hypothesis, modeling, calculation, etc.), conclusion, appendix, reference, vocabulary, etc. In addition, each group needs to prepare a

presentation to introduce the case of demonstration analysis. The assessment of case study is that written report is 50% and presentation is 50%.

The students can obtain many abilities by training of case study, such as lifelong learning ability, communication and language skills, critical thinking, problem solving skills, innovative thinking ability, teamwork ability, ability to access information, ability to write reports, the ability to use modern tools required for engineering practice and so on.

E. Home work

The homework is no longer the same as before. They are not only from the exercises in the textbook. The assignments are mainly from the exercises of the 'TN06 --- Transmission des efforts en mécanique' course at the University de technologie of Compi ègne (In France); MIT Exercises for the Open Course Mechanical Design and Manufacture 1 course; there are also some exercises that retain the domestic textbooks. This course will combine three parts of the exercises, considering with the characteristics of the students of the Institute of mechanical and electrical engineering and related courses, to form the homework of this course.

F. Lab work

According to the experimental conditions of the school of mechanical and electronic engineering of the University of Electronic Science and Technology of China, the six experiments can be provided as follows: 1) Mechanism motion diagram mapping experiment; 2) Gear box disassembly and installation experiment; 3) Gear basic parameter determination experiment; 4) Shaft structure layout experiment; 5) Gear shaper kinematic chain analysis experiment; 6) Mechanical transmission performance parameter test experiment. The traditional teaching experiment is to provide students with experimental content. students have no choice, and just finish experiments according to the process and arrangement. In the new teaching mode, Students in this reform can freely choose three according to their knowledge points and interests. Breaking the previous experimental process which students do not get effective practice. The experimental report and experimental process will serve as the main assessment basis for the lab work.

G. Assessment

In order to break through the shortcomings of cramming education, this course greatly reduces the proportion of paper-based examinations to 45%. The contents of inquiry-based discussion, case study and presentation were added. Based on the mentioned above, the assessment mode of this course are as follows: final examination (45%), inquiry-based discussion (20%), case study (15%), homework (10%) and lab work (10%) = 100%. The assessment mode is shown in Table 1. This diversified way of assessment breaks the standard answer as the only basis of the assessment mode, reflects the assessment of students'

ability training process. It can effectively train and exercise students' multi-faceted abilities.

Those seven aspects totally reform the mode of traditional teaching. The training abilities of each aspect are listed in Table 2. We can find that first two goals (outcomes of education) is reached.

III. OPERATION AND IMPLEMENTATION

The content of the reform is implemented in the school of mechanical and electrical engineering in University of Electronic Science and Technology of China. The students are 2015 grade of industrial engineering major. For mechanical engineering design course, 26 hours of classroom teaching, 14 hours of inquired-based discussion, case study presentation 2 hours, lab work 6 hours, a total of 48 hours. The number of students is 24. For inquired-based discussions, the number per group is 3-4.

After the implementation of the reform content, the results are shown that the attendance rate in class was 100% without checking attendance. The result of students' evaluation is excellent. Students show that they like this mode of teaching. In this course, besides learning the relevant professional knowledge of mechanical engineering design, they also learn a lot of other knowledge, get a lot of exercise, and their abilities have been greatly improved, such as learning ability, access to information, communication ability, expression ability, ability to write reports and do presentation, etc.

IV. CONCLUSIONS

This study explored and practiced inquiry-based small-class teaching mode on the students' learning and competent abilities training. During teaching section, inquiry-based discussions are designed in the teaching procedure. This mode changes the way of education from teacher teaching to student actively learning. For the topics in discussions sections, students need to find and survey literatures, discuss with the partners, argue and defend his/her views, accurately analyze and calculate, and present his/her group outcomes etc. The whole process trains student's composite ability. These abilities can make students play well his/her role of job after he/she finishes the study. It meets also the requirements of the Accreditation Board for Engineering and Technology (ABET). In addition, small-class means that this mode reduces the number of students to around 20 in one time, instead of big class traditional teaching. The small-class makes more students focus on the learning and no students wander in the class. The inquiry-based small-class teaching mode was practiced in industrial engineering major of University of Electronic Science and Technology of China (UESTC) for one semester. The good effects of teaching mode were fed back from student's side. The students attended new mode reflected that they liked this mode of teaching and obtained lots of trainings. As a result of the findings, the inquiry-based

small-class teaching mode is an effective tool to improve the learning efficiency and competent abilities of students. Similarly, the content and mode of this reform can be applied to other courses of engineering education.

TABLE 1. ASSESSMENT MODE

Activities	Reasons	Percentages
Final exam	Scores	45%
Discussion in divided group	Attitude, results, cooperation, notebook, etc.	20%
Case study	Report and presentation	15%
Homework	Each assignment	10%
Lab work	Reports	10%
		100%

TABLE 2. TRAINING ABILITIES

Abilities	Activities
Lifelong learning ability	Discussion in divided group Case study
Communication skills	Discussion in divided group Case study Lab work
Critical thinking	Discussion in divided group Case study Homework Lab work
Problem solving skills	Discussion in divided group Case study Homework Lab work
Teamwork spirit	Discussion in divided group Case study Lab work
Access information	Discussion in divided group Case study Homework
Use modern tools	Discussion in divided group Case study Homework Lab work
Apply basic knowledge of engineering	Final exam

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