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Practical Exploration on Project-based Teaching of Mechanical Engineering Testing Technology Course

Shuzhen Yang
College of Engineering
Shanghai Polytechnic University
Shanghai, China

Yu'an He
College of Engineering
Shanghai Polytechnic University
Shanghai, China

***Abstract*—Mechanical and Electronic Engineering is the first batch of undergraduate majors in our university——a local applied undergraduate university. As one of the important supporting technologies of Mechatronics engineering, Mechanical Engineering Testing Technology is set as the core course of Mechatronics engineering. In order to make students more in line with the social requirements of the new aera, it is necessary to carry out comprehensive reform and new exploration of teaching content, teaching methods and teaching resources. The project-based teaching mode is introduced into the curriculum construction, and step-by-step and hierarchical teaching methods are adopted to realize the "dual-subject" teaching of students and teachers. Through this innovative project-based teaching practice, students' practical ability and objectivity of evaluation have been greatly enhanced, and good teaching results have been achieved.**

Keywords—exploring, project-based teaching, Mechatronics Engineering Testing Technology Course, local applied undergraduate university

I. INTRODUCTION

"Project-based teaching" as a new teaching method was originated from the "dual system" vocational education model produced by German [1]. It is a kind of "behavior-oriented" teaching method [2]. Teachers and students complete relevant teaching activities through the joint implementation of a project [3]. In the process of project-based teaching, teachers will design specific tasks according to the syllabus, while students will use existing knowledge and experience and use learning tools such as network to carry out thematic inquiry activities, after learning, thinking and ultimately show the learning results [4]. On the one hand, project-based teaching can stimulate students' learning interest and subjective initiative, cultivate students' spirit of autonomy, cooperation and innovation; on the other hand, through project design, organization and implementation, assessment and evaluation process, it can effectively play the role of practical education, realize the transformation from teacher-centered to student-centered, and from knowledge system to practical ability. This paper discusses the practice of project-based teaching in Mechanical Engineering Testing Technology in our school and summarizes the relevant experience. It can be found that project-based teaching improves students' interest in learning so as to have a deeper and more comprehensive grasp of relevant professional knowledge.

II. CURRENT SITUATION OF TEACHING MECHANICAL ENGINEERING TESTING TECHNOLOGY COURSE

Measurement Techniques of Mechanic Engineering is the professional basic course of mechatronic engineering major of our school, being one of the five supporting courses for the mechatronic engineering major ("machinery, electricity, liquid, sense, and computer") as well as the main course for the majors related to machinery. The course mainly studies the mechanism, structure, measurement circuit and application method of all kinds of sensors, including common sensors, modern new sensing technology, signal conditioning circuit and interface technology between sensors and microcomputers. Through the study of this course, students can master the basic principle and application foundation of common sensors, and have the ability of detection and control system design. It features strong practicability and applicability, serving as the necessary foundation for students in carrying out various university students' technology activities and small inventions. It is extremely important for the students of the major to complete the graduation design and an important major course in improving the application capability and manipulative ability of students in the machinery majors and trigger their innovative thinking.

III. CONTENTS OF COURSE CONSTRUCTION

In traditional curriculum content architecture, the related knowledge points are introduced separately according to chapters as "basic concepts, sensor measurement principle, signal conditioning, signal analysis, common usage test", and finally the various parts are integrated and applied. Theoretically, curriculum content architecture is complete. However, with the further improvement of the requirements of Applied Education in Applied Undergraduate Education, many years of teaching practice has sensed that the traces of theorization of this set of content system are overemphasized, and the transmission of knowledge points is isolated, which easily leads to the abstraction of teaching content. It is difficult for students to accept and mobilize enthusiasm in learning. At the same time, the basic

knowledge of this traditional theoretical system is overemphasized, and the proportion of comprehensiveness and practicality is relatively small. Students' hands-on thinking and hands-on cells are not really mobilized. It is difficult for students to understand thoroughly through the teaching of this course, and a typical test system is really designed and implemented. Now we adopt the content system structure of "taking engineering application and project introduction as the main thread" and practiced the project teaching. The course content is composed of 6 learning contexts shown as table 1 including "force testing", "revolving speed testing", "displacement testing", "vibration testing" and "computer automatic test system". Each learning context matches with one test method of typical physical quantity and project teaching is applied. Each context fits the design for one specific project. Knowledge points of the course is integrated into different projects for study and application according to the requirements of project implementation, in order to realize "learn by practice, practice by learn". The sequence of projects follows the cognitive rules, being from simple to difficult based on project content. It is organized from the easy to complicate step by step from common detection to computer automatic test. Such a stepwise project teaching could enhance the practicability of teaching content, trigger the imitativeness of students' learning, facilitate the participation of students and thus effectively upgrade students' ability of comprehensive knowledge application.

In terms of engineering project selection, it shall give priority to the typical engineering context of "bicycle intelligent factory" to develop specific features.

TABLE I. CONTENTS OF COURSE CONSTRUCTION

No	Learning Context	Context Project	Main knowledge point	Class hour
1	Measurement Techniques of Mechanic Engineering	on the basis of bicycle intelligent factory context	Typical test system composition Sensor definition and classification Measuring error Signal description Basic analysis method of signal	8
2	Force testing	Design of simple electronic scale strain force sensor	Weighing sensor Measuring circuit (bridge); Conditioning circuit (amplifying circuit)	8
3	Temperature testing	Electronic thermometer design	Thermocouple temperature measuring Thermal resistance temperature measuring Integrated temperature sensor	4
4	Revolving speed testing	Bicycle revolving speed measuring	Revolving speed measuring approach and method Photoelectric sensor Hall sensor Magnetic electrical sensor Proximity switch	4
5	Displacement testing	Bicycle hub beating degree measuring	Minor displacement measuring method Capacitive, inductive, eddy current-type sensor Filter technique Optical grating and coder Measured data analysis and waveform display	8
6	Vibration testing	Cantilever beam intrinsic frequency testing	Vibration test method Piezoelectric sensor and measuring circuit Common vibration measurement sensor and selection Signal analysis (spectral analysis, digital filtering)	8
7	Computer automatic test system	Bicycle performance automatic test system	Computer test system composition Computer acquisition technology Computer automatic test system based on labview#VB#VC and PC machine	8

IV. TEACHING METHOD AND APPROACH

A. Four-step Method

On the basis of project content, it adopts "four-step method" to organize theory teaching and realize the student and teacher "double subjects" teaching.

Project requirements: teachers raise the actual project and project requirements to introduce the learning context of this unit.

Project knowledge preparation: teachers analyze project simply, introduce relevant knowledge points related to projects and list learning requirements of knowledge points. Students look up relevant documents after class. When they back class, teachers and students would make knowledge learning with the approach "teacher raises questions, students deliver report, teacher make summary".

Project analysis and design: under the guidance and enlightenment of teachers, teachers and students discuss the design of project together.

Expansion training: on the basis of the learning context of the unit, it makes expansion on certain knowledge points. Teachers arrange tasks and students look up documents after class. The results would be delivered through report. In the "four step method", teacher and student take turns to be the subject over teaching process, which is the so called "double subjects". In this way, it could effectively give play to teachers' functions of inspiration, guidance and monitoring and also trigger students' learning interest, enhance learning impression and intensify learning effect.

B. Layered Practice Teaching Model

It designs "layered" practice teaching model. As shown in Fig 1. Practice teaching includes experiment teaching in class, experiment teaching out class and comprehensive

practice teaching as shown in Fig 1. The experiment method combining in-class practice and out-class practice is applied, which enhances students' initiatives in the practice teaching. Students of different layers can receive different treatments. For instances, students with better academic performance would receive expansion experiment and difficult comprehensive practice content. In this way, their engineering application ability and innovation ability could be enhanced.

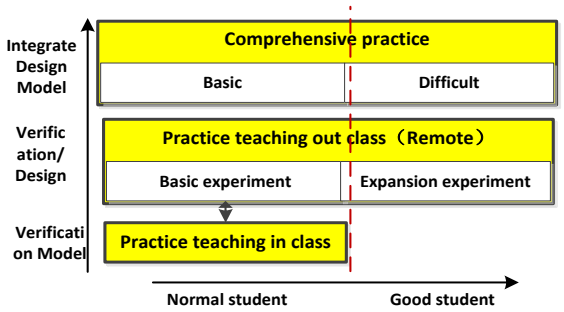

Fig. 1. Layed practice teaching mode

C. Student Subject Orientation Experiment Teaching Method

It adopt the "student subject orientation" experiment teaching method combining physical experiment and remote virtual experiment The experiment course is completed by combining virtual experiment beyond class and the experiment in class. Students shall first complete the virtual experiment beyond class, get familiar with experiment content and procedures and they do the experiment in the laboratory. Student is the subject over the experiment process. They select experiment content and complete experiment independently. It would abandon the traditional teaching method of "experiment content shall be the same and be designated by teachers, experiment process is demonstrated by teachers, and students copy the verification process. Teacher would only give tutorship or make demonstration. This method could not only practice students' independent thinking and manipulative ability, but also settle the contradiction between few experimental class hours with much experimental content. Similarly, independent practice content and implementation are selected and completed by students independently. Teachers only give instructions. The contradiction of "more content and less hours" in the experiment has been solved, and the experimental process of "students' autonomy" has effectively improved the students' ability of self-study and independent thinking. The detailed experimental contents shown in table II.

TABLE II. CONTENTS OF EXPERIMENT

No	Experimental name	Content and Requirements	Class hours	Experimental type	Experimental requirements
1	Sensor Principle	Strain sensor	2	Verification	Compulsory (Select 1 from 3, Remote+ Practice in class)
		Hall sensor			
		Capacitive sensor			
2	Signal Analysis and Processing Experiments	Typical signal synthesis experiments. Understand and master the principle of signal synthesis. The synthesis procedure of a typical signal is designed by ourselves	2	Verification Design	Elective (Remote + after-class coaching)
		Experiments of typical signal spectrum analysis. The spectrum characteristics of each typical signal were observed. A program for spectrum analysis and digital filtering of a typical signal with noise is designed.		Verification Design	Compulsory (Remote + Practice in class)
3	Vibration Testing	To set up a typical vibration measurement system, it is necessary to select suitable sensors, install them correctly, connect them accurately, collect the measured signals and analyze and display them.	2	comprehensive	Compulsory (Remote + Practice in class)

D. OBE-Oriented Comprehensive Practice Teaching Method

In order to strengthen students'comprehensive application ability of undergraduate course knowledge points, cultivate their practical ability, innovation ability and cooperation ability. In addition to the theoretical course, two weeks of comprehensive practice were added.

Comprehensive practice requires the development of a practical modern mechanical engineering test system in the form of team work. Students will experience the whole process of the development of computer-based automatic test system, including the design of the overall system scheme, circuit design and simulation, circuit board design, production and welding, programming (computer acquisition, analysis, display program). The result of the course is that students must complete the construction of a test system in physical form and achieve the desiged effect.

The course provides 20 projects for students to choose from. Each project contains specific tasks as follows:

1) The overall design of the computer test system: It includes the selection of sensors, the design and Simulation of measurement circuit, the design and Simulation of signal conditioning circuit and the selection of acquisition card.It needs 12 course hours.

2) Hardware fabrication, connection and debugging of the test system: Including related circuit board design,

fabrication and welding, sensor installation, signal connection and debugging of each module of the system. It needs 12 course hours.

3) Software design of test system: Including data acquisition program design, data analysis and processing program design, data display and save program design. It needs 10 course hours.

4) Overall debugging of software and hardware: It needs 10 course hours.

5) Writing reports: It needs 2 course hours.

The implementation of the comprehensive practice is mainly carried out by student-centered, teacher-assisted and project team.

E. Online Teaching

It carries out online teaching and tries micro-course online video approach, which enriches the extracurricular learning model of students and enables them to make independent learning. It utilizes the online platform of school course center to upload teaching documents, reference documents, materials used in class teaching, animation resource and learning documents. Students could get teaching information online, which facilitates their independent study. Beside, students could also make discussion and communication with teachers through website.

V. COURSE DEVELOPMENT FRUIT SUMMARY

It preliminarily constructs the course system framework of "project introduction type teaching and discards traditional theoretical teaching content system taking knowledge point as the main thread. In the new course system, the typical engineering quantity test serves as the main thread. These typical engineering quantity tests are integrated with simple, complex, single and multiple varieties, ranging from common test system to computer test system and being organized by layer from easy to complicate. The content of each typical engineering quantity test adopts corresponding typical test project to make introduction. It then analyzes project requirements, interprets necessary knowledge points according to the thinking pattern completing projects and makes specific discussion on specific knowledge point. The whole project would be completed when it finishes the discussion on all knowledge points. In this way, the whole teaching always implements the organizational model "start from practice, return to practice". Specifically speaking, it is "project requirements (start from practice) →problem analysis → relevant knowledge point learning → problem solving → project completion (return to practice)". Each chapter is practicing and intensifying such a project implementation process continuously. Practice demonstrates that such a new course system framework is more suitable for the student features of modern application-type undergraduate education and the cultivation requirements of this course. It could effectively improve teaching effect. Therefore, the development of this course's other aspects including teaching method, experiment teaching and teaching material designing would follow this direction. They would be included in this framework for integrated development.

It accumulates rich "industry-university-research cooperation" project cases to provide abundant material for the project teaching reform. The research of "industry-university-research cooperation" projects provide diversified materials for project teaching, which effectively enhances the practicability of teaching content and triggers students' interest on the course learning.

It constructs the machinery engineering test laboratory and network teaching environment. The excellent conditions provides hardware safeguard for the course development. The machinery engineering test laboratory which has been put into construction in the previous phase has shown the primary shape, featuring multiple sensor experiment benches including rotor monitoring experiment table, annular convey line experiment table, displacement test system experiment table, environment monitoring and cantilever beam experiment table. Besides, it has been equipped with diversified inspection device and equipment, including the various data collection card of Advantech, multiple data collection card of NI, signal generator, oscilloscope and spectrum analyzer. All of these enable it to meet requirements of course experiment, practice and research. Online teaching environment has been established, with the course website being in place in the course center of school. This website provides the expansion documents facilitating students' independent study, including outline, instructor, auxiliary materials, examination database and PPT.

VI. CONCLUSION

Through exploring the project-based construction of the course "Mechanical Engineering Testing Technology", the curriculum design has been further optimized, the enthusiasm of students' participation has been enhanced, and good teaching results have been achieved. On this basis, the next step can be to further improve the assessment mechanism and teaching means, and continuously promote the course construction.

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