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Exploration and practice: A competition based project practice teaching mode

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ABSTRACT

In recent years, known as multi-discipline, integration, product and system, mechatronics education has drawn worldwide attention. On the foundation of 7 years' mechatronics education experience, and taking the characteristics of Chinese undergraduate students into consideration, Beihang University improved the previous teaching mode, and formed a competition based project practice teaching mode. After one year's exploration and practice, this mode more easily stimulates the enthusiasm and initiative of students, enhances their hands-on ability, innovative thinking and teamwork spirit. The experiment achievements and feedbacks from students prove that this mode largely realized the goal of the course.
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1. Introduction

Defined as "synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes" [1,2], mechatronics has attracted great attention from engineering undergraduate students [3]. Mechatronics emphasizes multi-discipline, integration, product and system thinking [4], and is widely applied in either scientific research at colleges, or products development in enterprises. After grasping the knowledge of mechanical design, electronic circuits, control theory, high-level language programming, students should digest, absorb and integrate the theory knowledge to develop a new product with some functions, which reflects their comprehensive capacity to apply the knowledge to practice and hands-on ability. On this basis, students can freely spread their imagination and perform innovative thinking.

Internationally, many institutions have accumulated valuable mechatronics teaching experience for a long time, with various methods, and achieved better results. University of Detroit Mercy (UDM) focuses on solving the problem that engineers are traditionally trained in programs which concentrate on either mechanical or electrical engineering, and not well prepared to environments with integration knowledge. They summarized the features of the way in which mechatronics courses have been integrated in parts of precollege activities, undergraduate curriculum, and graduate curriculum [5,6]. Concerning the lack of innovative commercial products recently in society, and aiming at meeting the demand of economic growth, educators in Marquette University proposed the STEM (Science, Technology, Engineering, Mathematics) discipline. STEM students, as well as students from the humanities, arts, social sciences and business collaborate to creatively develop a product [7]. In Georgia Tech, competitions are integrated into mechatronics education. Faced with students in different levels of and different phases, three types of competitions are to be completed in six weeks [8,9].

In China, PBL (Project Based Learning, PBL) teaching mode in Tongji University has achieved better results, and is still making continuous improvements [10]. They aim to cultivate students with solid engineering practice ability to meet the demands of domestic manufacture industry. The goal of the course is to equip the students with competitiveness in automation, automobile and electronic products, as well as communication and understanding skills under multi-discipline, multi-culture and multi-language environments. More importantly, train students with a wholesome personality [11]. The Northeastern University adopted a modular robot platform, "NEURobot", to encourage the creativity and imagination of the students, while ensuring that students put fundamental laws of control into practice [12]. In National Changhua University of Education, group projects are an integral part of the undergraduate mechatronics course. Students are allowed to practice the topics covered in the course and fulfill project requirements, according to their interest. A proposal is required as a preliminary scheme and schedule line of the project [13].

At present, with the increasing number of Chinese undergraduates, the mechanical engineering students mainly learn theory

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knowledge on mechanism, electronics, and control fields at the early stage of college. The isolated teaching and mutually independent knowledge structure cannot be integrated and applied by students. Meanwhile, in the exam-oriented education background, students have few opportunities to practice what they have grasped, weakening their engineering application ability. What's more, with the implementation of one-child policy in China, the majority of students grow up in a relative independent environment, making them lack the cooperation and coordination consciousness [14]. However, the teaching modes mentioned above didn't consider the combination of students' hand-on practice and creative thinking, neither did they have an explicit and objective criteria. The issue "A Mechatronics Control Engineering Class at Beihang University, China: Practicing and Exploring" [15] gave a detailed introduction of the 6-year PBL teaching mode of mechatronics education at Beihang University, which aims at improving students' integrated application ability of multi-discipline knowledge and hands-on ability, and achieved good results. This year, this course transforms the teaching method, and proposes a CBL (Competition Based Learning, CBL) project practice mode on the previous basis. Driven by the competition indicators, students' enthusiasm and initiative to apply knowledge into practice are largely motivated, their creative thinking can put into good use, their teamwork spirit are trained. The features of CBL, summarized as competition based, project practice, team division of labor and cooperation, promote the mechatronics teaching to acquire favorable results.

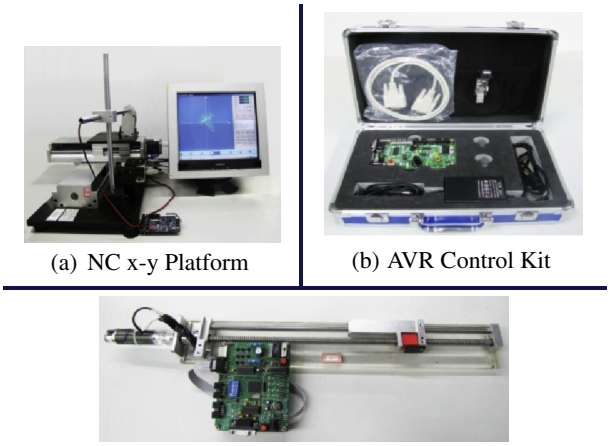
2. Teaching method

2.1. PBL teaching method

The PBL teaching mode takes the studies of the principle of a certain concept or a variety of disciplines as the center, aims at projects, carries out activities through diversified resources, and solves a series of problems in a limited time [16]. This method organizes the study activity through a specific project, transforming the traditionally knowledge impartment centered method into the interactively problem solving and task implement method. Combining with professional knowledge, students grasp the overall task, decompose it and plan the steps, actively exploring the learning approach and completing the task under the guidance of the teacher. This method regards the students as center, projects as direction. The role of the teacher turns from "teaching" to "guidance", training students to think over, analyze and solve problems, apply their theory knowledge into concrete tasks and deepen the understanding of what they have learned.

The mechatronics course in Beihang University is one of the basic courses for mechanical engineering students, and is a comprehensive and practical core course in the control field. It is arranged at the third academic year, the prerequisites of which include Mechanical Design, Basis of Mechanical Control Engineering, Motor Drive and Control, Testing Technology, Principle of Microcomputer, and Basics of Computer Software Technology.

Through 6-year exploration and practice, the PBL practice teaching mode of mechatronics course in Beihang University has achieved good results [17]. In the early stage of the course, teacher introduces basic knowledge and application examples of mechatronics, including mechanism, sensor, driving and control, to construct an overall theory knowledge structure. In the practice part, this course takes a typical mechatronics system – Double Coordinates Numerical Control Platform (Fig. 1a) as the main line. Students successively complete the project proposal, Matlab modeling and simulation of DC motor (Fig. 1b), PID control of linear motion unit (Fig. 1c) and finally design of double coordinates



(a) NC x-y Platform (b) AVR Control Kit

(c) Linear Motion Unit

Fig. 1. Students experiment devices in PBL.

numerical control platform [18]. In the process, students conceive and plan the project, analyze the theory principle, design the scheme, simulate the model, and at last program and debug, which corresponds to the process of learning, cognizance, practice, feedback and deeply understanding of the knowledge. In the course, students integrate the mechanical design, electronic circuits, computer programming, signal processing, etc. knowledge they have learned, and use them in the closed-loop velocity control of DC motor, laying the foundation for the realization of more complex mechatronics system, shown in Fig. 2.

2.2. CBL teaching method

However, the long-time fixed tasks and indicators in the PBL teaching method make the students feel tedium and boring, and cannot stimulate their initiative and creative thinking. As a result, the adoption of teamwork competition method adds students' impetus to study and practice. The CBL method emphasizes the development of students' comprehensive quality and ability, aims at improving their active and initiative study attitude, trains their creative awareness and highlights competition and cooperation, possessing the following features:

- The competitions between groups improve students' ability to endure failures, help them to find deficiencies and constantly perfect themselves, foster innovation ability.
- In the process of a team to complete a task, there exists division of labor and cooperation. The common goal cultivates the students a strong sense of cooperation spirit.
- When discussing about the scheme, students in a team actively express their views. Meanwhile, they should learn to understand and respect others, listen to different opinions and get along well with their partners, thus developing students' positive, inclusive and healthy personality.

In the CBL project practice teaching of mechatronics course at Beihang University, students are given a set of experimental equipment, and complete certain tasks under constraint conditions and rules, without limitations on methods and steps. The course provides open experimental sites and competition fields, and periodical guidance from the teaching assistants. Students can also use additional devices to meet the target. The competition time should avoid important tests and exam week, so that students have plenty of time and effort to prepare and implement the experiment.

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