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# A problem-based innovative teaching model for the mechatronics specialty

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ABSTRACT: The educational goal of the mechatronics specialty is to improve students' self-learning and research ability, as well as to provide them with sound theoretical foundations and rich practical experience. The PEDC (problem, exploration, discussion, case) innovative inquiry teaching model is proposed in this article. A comparative study of two classes of mechatronics specialty students, forming an experimental and control group, was undertaken. The research results indicate that PEDC teaching can enhance significantly students' learning interest, their academic results, innovation ability and project capability. Therefore, PEDC teaching can improve the teaching of the mechatronics specialty, and is of great significance in promoting engineering education.

## INTRODUCTION

The mechatronics specialty is a comprehensive technical discipline that integrates microelectronic technology, machinery, information systems, and control and detection technology, with other subjects. At present, mechatronics technologies and products have penetrated into many fields, and have become the mainstream of modern technological development. Meanwhile, social and economic development has resulted in an increasing demand for professionals who are specialised in mechatronics [1]. Cultivating mechatronic talent with profound theoretical knowledge, strong research capability and creativity, has become a priority for reform in colleges and universities. China also has an urgent need for professionals with the compound talents of microelectronics, computers and other specialties.

## ANALYSIS OF THE TEACHING PROBLEMS IN MECHATRONICS BASED ON PROBLEM-CENTRED LEARNING

### Traditional Model of Mechatronics Teaching is Dull, Emphasises Theory and Ignores Experiments

At present, most machinery and electronics knowledge systems involve abstract concepts and cumbersome theories. Courses are interlinked, but there are too many schematics and abstract narratives to understand the interrelationships. Students cannot relate the material to real objects, and generally are bored during learning. For example, when studying sensor and testing technology, students' knowledge about the sensing element is just a structure diagram; they do not see the real object, and have very little knowledge of the mechanical structure of its components or their working principles. This severely affects their learning interest, and leads to the situation where students fail to fully grasp the concept of the system [2]. In addition, students have only superficial understanding of the mechatronics specialty, with poor practical ability.

### Traditional Problem-Based Learning and Inquiry Teaching is Inadequate

Traditional problem-based learning involves verifying course knowledge by experiment. Students can master and understand the basic principles and application of the knowledge from a single discipline area by this approach; but students cannot grasp the co-ordinated application of knowledge from different areas, and cannot develop the required analytical and problem-solving skills.

Most universities in China adopt a teacher-oriented teaching model. Teachers select the topic of an experiment, and students passively repeat the procedures according to the test requirements. The teaching material is often old, whereas new technology is being constantly updated. Also, teaching hours have been adjusted or shortened. How to improve teaching quality and integrate learning with enterprise practice is a major problem facing the teaching of mechatronics.

Lack of Equipment Means Teaching is by Demonstration

Most colleges and universities now offer experimental courses in mechatronics. However, because the experiment equipment is bulky and expensive and colleges do not have sufficient funds, the experimental courses have little equipment [3]. Most experimental teaching classes are just demonstrations. The teacher is in charge of the experiment, which the students observe. Even in hands-on classes, students just repeat the operations according to the teacher's instructions.

Some experiments are not comprehensive, carefully designed or representative, and so tend to be formal. This is not conducive to cultivating students' independent innovative and creative ability, and cannot inspire students' enthusiasm to participate in the experiment. This, in turn, results in poor problem-solving ability.

## DEFINITION AND APPLICATION METHOD OF THE PEDC INNOVATIVE INQUIRY TEACHING MODE FOR MECHATRONICS

In view of the existing issues in problem-based learning of mechatronics, the author proposes the PEDC (problem, exploration, discussion, case) teaching model. This innovative teaching model was applied to the mechatronics specialty, in order to greatly improve the teaching.

The problem-based PEDC teaching model features the cultivation of vocational ability as the main aim. Theory is combined with practice, so as to strengthen students' overall and innovative ability. The PEDC teaching abandons the traditional model of just passing on knowledge in theory-based courses. Instead, it stresses students' ability to apply knowledge, independent learning and independent research abilities.

According to the essential capabilities, required knowledge and necessary training requirements, mechatronics teaching should be systematic and complete [4]. Therefore, the mechatronics specialty requires a curriculum that integrates theory with practice and enables students to master professional technical application skills.

Therefore, when developing the curriculum for mechatronics, the relevant teams at colleges and universities should consider the multi-disciplinary features of the specialty. The proposed PEDC curriculum is shown in Table 1.

Table 1: Mechatronics curriculum.

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|---|---|---|
| Traditional mechanical basic skills | Required skills | Students should be able to test and design mechanical parts, repair and debug general machine tools, design fixtures and formulate processing specifications. |
| | Core course support | Mechanical design, graphical plot and CAD drawing,<br>Mechanical manufacturing,<br>Metalworking practice. |
| | Practice | Metalworking practice and mechanical design, comprehensive training,<br>Mechanical manufacturing technology integrated training,<br>Machine tool control training. |
| Modern mechanical and electrical equipment regulation, management and maintenance | Required skills | Students should be able to understand and operate modern electrical and mechanical equipment, regulate and repair mechanical elements, sensors, various types of PLC, microcontrollers and other control components. |
| | Core course support | Electronic technology,<br>Hydraulic and pneumatic transmission,<br>Machine tool electrical control and PLC applications,<br>Mechatronics technology foundations. |
| | Practice | Electronic technology, hydraulic and pneumatic transmission course design, microcontroller principles, applications course design, as well as other comprehensive training. |
| Advanced manufacturing technology | Required skills | Students should be proficient in numerical control machine tools, wire-electrode cutting, the machining centre and other facilities, as well as the flexible program and design of 3D models. |
| | Core course support | Mechanical CAD, numerical control. |
| | Practice | Mechanical CAD, NC skills training. |

The mechatronics course covers theory, technology and the application of all branches of electromechanical technology; each branch of electromechanical technology is a microcosm of a modern high-tech area. Relevant teams at colleges and universities should establish appropriate information platforms, including classic courses and system simulations, an examination database, an exercise database, and so on. As well, they should carry out dynamic management of the platform, to enable teachers to track in a timely way student data and interactions, so as to understand their mastery of the knowledge [5].

Meanwhile, colleges and universities should make full use of on-line teaching resources, according to the characteristics of the mechatronics technology course, and to improve students' ability to acquire technology and knowledge, as well as practical ability. Therefore, the author proposes a curriculum design based upon the following principles:

- On-line, case-based teaching:

  The relevant teams at colleges and universities should carefully define the modules, such as mechanical system components, electromechanical actuators, electromechanical computer controls, electromechanical component characteristics and electromechanical integration. Students should take full advantage of Web searching tools to study on-line. They should retrieve and review relevant preliminary material, and acquire, compare and discuss relevant design cases, so as to gain an in-depth understanding of the mechatronics systems. As a result, students will enhance their interest in the course and be motivated for subsequent learning.

- Electromechanical products driven by enterprise needs:

  Electromechanical technology is developing very rapidly, which accelerates the replacement of products. Therefore, the teams at colleges and universities should engage with mechanical and electrical enterprises, to investigate enterprise needs. Students should participate in the innovative design of enterprise products, e.g. as part of the graduate project. The teacher should give guidance, to integrate mechatronics theory with practical applications.

The PEDC Innovative Teaching Method

Economic and technological development creates new requirements for mechatronics skills. Mechatronics skills require a solid theoretical foundation and excellent analytical and problem-solving skills [6]. The PEDC teaching model combines teaching with research and practice; observes the principle of *starting from shallow to deep, from concrete to abstract and from simple to complex*; and forms a multi-level progressive teaching model [7]. Specifically, it includes experimental practice teaching, problem-based research and an innovative student appraisal system.

- Experimental practice teaching:

  Mechatronics technology is used widely in various types of product, such as NC machine tools, industrial robots, cameras, iPhones and automatic punched-card machines. This reflects the interdisciplinary nature of electromechanical technology. Therefore, the teams at colleges and universities should make full use of experimental teaching resources, NC machining centres and on-campus mechatronics laboratory equipment, so as to provide students with a variety of opportunities by which to learn real-life mechatronics technology. This widens the learning space of students and broadens their horizons.

- Problem-based research learning:

  The essence of the problem-based research learning proposed by PEDC is that of designing and presenting the topics for study. It requires students who seldom engage with electromechanical practice to independently propose course-related questions. In view of this, teachers should design problems and ask students to form learning groups to carry out research-based learning. Teachers should design problems, which reflect cutting-edge, frontier topics for research and projects. The content should combine the teaching syllabus with mechatronics as it occurs in the field.

  Teachers should provide references, so as to reduce the difficulty for students of exploring the research subject. For research, teachers should ask students to establish a correct analytical model to study the research subject in terms of depth and precision, know the technical details of problems in the study, and to make an in-depth qualitative and quantitative analysis. In studying research questions combined with practice, students' learning will deepen.

- Innovative appraisal system:

  The PEDC student-appraisal system focuses on students' basic theoretical knowledge, their practical ability and their problem-solving ability. It also gives consideration to the teaching objective, as well as to student reaction and the social feedback. It overcomes the problems of the traditional assessment method, whereby, the focus is only on a single-test performance. Hence, the assessment is transformed, from one that is a single perspective, to that of a multi-dimensional perspective [8]. The appraisal includes professional teaching practice, a final examination, an innovative research project and school performance in the academic year. The appraisal system not only evaluates the outcome of the project, but also emphasises the assessment of the learning process [9].

  The PEDC student-appraisal system should be developed and implemented, and professional development should be combined with students' self-development, in order to fully mobilise students' enthusiasm for independent learning, exploration and creativity.

## IMPACT OF PEDC TEACHING ON ENGINEERING EDUCATION

The application of PEDC teaching was found to have significant impact on engineering education at colleges and universities. In order to verify the teaching results of this model, the students who majored in the mechatronics specialty at Chifeng Industry Vocational Technology College were used as the research subjects. Two classes of the 2012 year were studied. Each class had 35 students; one class was the control class and the other, the experimental class. Traditional teaching was adopted as the method for the control class, and PEDC teaching was the method for the experimental class. Results indicate that:

- Elective courses:

  The number of elective courses taken by a student can reflect their interest in the course. On this basis, the PEDC teaching significantly improved student interest. As shown in Figure 1, 94% of the students in the experimental class chose elective courses, as compared with 80% of students in the control class.

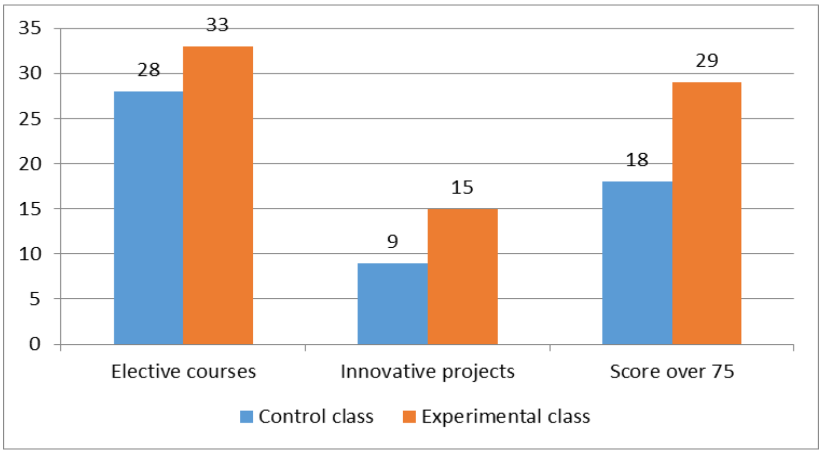


Figure 1: Elective rates, innovative projects and score over 75 for the control and experimental classes (Grade 2012 students, who majored in mechatronics).

- Innovative projects:

  It was found that the PEDC teaching can enhance a student's capacity to undertake innovative projects. As shown in Figure 1, after one year of study, students in the experimental class completed 15 innovative projects, while students in the control class completed nine.

- Comprehensive score results

  The PEDC teaching can improve students' comprehensive scores. As shown in Figure 1, 29 students in the experimental class achieved a score over 75, accounting for 83% of the experimental class scores. By comparison, 18 students in the control class achieved a score over 75, accounting for 51% of the control class scores.

After studying the application of the problem, exploration, discussion, case (PEDC) teaching to students in the mechatronics specialty at ChiFeng Industry Vocational Technology College, it can be seen that PEDC teaching can stimulate students' intrinsic motivation for learning, improve their interest, their innovative and research capacity, as well as their overall performance.

## CONCLUSIONS

In summary, problem, exploration, discussion, case (PEDC) teaching integrates the teachings with learning, to enable teachers and students to participate in the teaching practice to achieve the desired teaching outcomes. The application of the teaching mode for the mechatronics specialty demonstrates a very good effect on the teaching. It greatly enhances students' learning interest, as well as their academic results, innovative ability and project capacity. Therefore, the mechatronics specialty teams at colleges and universities should extensively apply the PEDC teaching model, thereby, enabling them to provide a large number of high-quality graduates for society.

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