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Teaching reform of an *Automatic Measuring Technology* course based on the CDIO method

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ABSTRACT: A teaching reform is suggested in this article, based on the CDIO (Conceive, Design, Implement, Operate) method. The aim of the reform is to overcome disadvantages of the traditional teaching of a course, Automatic Measuring Technology. In this study, the class was divided into several projects. The combination of both a project and appropriate teaching can help to develop students' abilities and skills. The results of this study suggest that application of this reform, based on the CDIO method in automation system engineering, has demonstrated considerable advantages and benefits, and is expected to prove popular.

INTRODUCTION

Automatic Measuring Technology (AMT) is a basic course for students whose majors include electronics, control systems, electro-mechanical engineering and photoelectric technology. The course combines technology with theory and deals with how to acquire, convert and handle information from control systems and electro-mechanical devices. Because it is both comprehensive and disparate, teachers and students consider it to be a difficult course. A key reason for this is that students taught by traditional educational methods have a poor practical, hands-on ability. Such students do not meet the needs of society.

The Conceive, Design, Implement, Operate (CDIO) mode of project delivery has been widely adopted by many universities in China and abroad [1-3]. The CDIO method enables students to use classroom learning so as to design, market and operate their own products [4]. The CDIO method has been successfully used in many courses, such as computer design, software design and material science. However, applying the CDIO method to the course, Automatic Measuring Technology, is less common.

The traditional education approach to teaching this course focuses on the basic knowledge of the subject, including basic formulae and analysis, rather than the real applications of sensor technology [5]. In order to upgrade the traditional educational mode, CDIO was introduced into the Automatic Measuring Technology course. The Conceive, Design, Implement and Operate mode was found to improve students' learning and ability.

CURRENT PROBLEMS

The course structure for Automatic Measuring Technology is divided into two parts: theory and practice. The following problems are obvious, and can be listed as follows:

- Theoretical analyses are difficult because the content concentrates on pure theory and not practice. Students need a good understanding of mathematics, physics and electro-technology to understand the theory.

- It is most difficult for students to grasp all kinds of measuring methods and devices, because various types of sensor have different measuring methods. Also, the same target could use many types of sensor to take measurements. There is a many-to-many relationship between targets and methods.

- Theory is divorced from practice. For the students with an application-bias, the focus is on how to use sensors and not how they work. They only know how sensors convert a measured value into a voltage. But, they do not know how the sensors work.

In order to improve teaching quality and students' innovative and project abilities [6], an investigation was carried out among students and teachers at Xi'an Technological University to gauge the level of satisfaction with the course. The results, which are listed in Table 1, show the need for reform of this course.

Table 1: Satisfaction with the Automatic Measuring Technology course.

Role	Course %	Teaching methods %	Theory %	Study aims %	Innovation %
Teacher	10.1	15.3	3.1	21.4	9.0
Student	8.5	27.4	8.5	23.5	12.9

DETAILED APPLICATION

Conceive, Design, Implement and Operate project education, in which project education can be combined with course teaching, was applied to the Automatic Measuring Technology course. Temperature measuring systems, as a traditional CDIO project, was introduced in the following manner.

Conceive Stage

An appropriate temperature measuring system was constructed according to different objects requiring temperature measurements, and using different sensors. Three temperature objects were used in this project, i.e. room temperature, forge temperature and tundra temperature. Students can choose any one of these.

In fact, different temperature objects have differing requirements and measuring ranges, which means that students have to choose different sensors for different objects. For measuring room temperature, because the precision is not high and the working environment is good, simple and low-cost sensors can be used, such as DS18B20, and SHT15.

For measuring forge temperatures, the working temperature is very high, and so a thermocouple sensor is appropriate. For measuring the tundra temperature, the precision is very high and it must work continuously, implying a thermo-resistance or heat-sensitive sensor.

Design Stage

During the conceive stage, an appropriate temperature measuring system would have been selected for the temperature object. Different temperature objects, i.e. room, forge and tundra temperature, need different sensors, i.e. DS18B20, thermocouple and thermal-resistor, respectively. The latter two sensors will need an analogue/digital (A/D) converter. After the sensor has been selected, the rest of the hardware can be designed.

The DS18B20 digital sensor has simple hardware, which requires a pull-up resistor to ensure the inputs settle at the expected logic levels. For a thermocouple, it is important to tell students how to calculate the real temperature based on the output voltage noting that the cold junction may not be at zero degrees Celsius (cold junction compensation).

For a thermal-resistor sensor, an R/V (reference voltage) converter circuit is required, using an active or passive bridge. For the last two sensors, an amplifier is required, which may be a differential amplifier circuit or a simple amplifier. During this stage, teachers should encourage students to work in teams creatively finding and solving design problems.

Implement Stage

After the design stage, a micro-computer is employed in the implement stage, viz. a CPU is used to measure the real temperature. Not only is the temperature monitored and displayed, but the temperature can be controlled automatically. The Microcomputer (MCU) Principles and Electric Automatic Design courses should have been taken by this stage.

The implement stage proceeds as follows: use a software package (e.g. Protel) to produce a printed circuit board (PCB) design. Build and debug the hardware. Produce the required software in an assembly or C language using appropriate tools (e.g. KEIL, IAR, ADS). Debug and download the software. Refrigerator, electric fire, thermostat and other equipment is used to create the different environments by which to test the design.

By this stage, students should have a good foundation of knowledge that they can apply flexibly. Teachers should work with the students to gradually develop their abilities. If difficulties appear in the design, the teachers should help the students to analyse and solve the problem.

Operate Stage

After the implement stage, the prototype has been finished, and can be used for making measurements [7]. However, it is very far from being a complete and comprehensive product. To learn how to make a fully developed product, students would need to communicate and co-operate with people in appropriate organisations. An experienced professor, expert or specialist could be invited to assess the product, during which the design, key technologies, working principles and operation of the product can be presented and discussed.

Students should consider how the cost of the product could be reduced while maintaining the requirements. Students could consider chip selection, manufacturing method and so on. Another important factor in developing a successful product is appearance. Hence, students should study how to select or manufacture a mould that results in a good appearance.

Moreover, students are encouraged to advertise and sell their product to the public. Finally, as a result of the entire exercise, they are also encouraged to publish articles about their products in scientific journals.

COURSE ASSESSMENT

The CDIO method is one where the traditional method of assessment is abandoned, solely based on a final examination, assessment. Conceived, Design, Implement, Operate provides a diversity of methods of assessment of basic knowledge, innovation, team co-operation by self-appraisal, and so on [8].

Because the product is designed by a group, and not just one student, assessment of the course should be carried out for each person in the group, in order to provide a fair assessment. Objective, individual appraisals spur initiative and motivation and are fair to the students. Each project's product must be demonstrated and checked as part of the assessment process. There is flexibility in the assessment of the course. Not only is the final result checked, but the working process can be checked and evaluated at each stage. The breakdown of the assessment is shown as Table 2.

Table 2: Items and ratio on Automatically Measuring Technology.

Item	Final examination %	Conceive stage %	Design stage %	Implement stage %	Operate stage %
Ratio	25	15	25	20	15

CONCLUSIONS

In order to address the existing problems of the traditional course, Automatic Measuring Technology, the Conceived, Design, Implement, Operate method was introduced. This integrates theory and practice based on a project education. In the CDIO method, basic knowledge, individual ability, team co-operation and project abilities are well developed.

At each stage of the project, all the students have opportunities to incorporate their own ideas into the real product. This promotes their interest in study, engineering ability, self-study aptitude, team co-operation and communication ability and skills.

The CDIO method was used in an experimental class of the Automatic Measuring Technology course, which is part of the automation major at Xi'an Technological University. All the students in the experimental class were satisfied with the CDIO method.

Further enquiries on course organisation, educational content, associating theory with practice, innovation training and other items show that the CDIO method can be implemented and expanded in the course, Automatic Measuring Technology.

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REFERENCES

1. Takemata, K., Kodaka, A., Minamide, A. and Nakamura, S., Engineering project-based learning under the CDIO concept. *Proc. IEEE Inter. Conf. on Teaching, Assessment and Learning for Engng.*, 258-261 (2013).
2. Hsu, J.C. and Raghunathan, S., Systems engineering for CDIO conceive, design, implement and operate. *Collection of Technical Papers - 45th AIAA Aerospace Sciences Meeting*, 7119-7129 (2007).
3. Xu, X. and Liu, M., Course reform of sensor technology based on CDIO method. *J. of Heilongjiang Vocational Institute of Ecological Engng.*, 25, **5**, 108-110 (2012).
4. Svensson, T. and Gunnarsson, S., A design-build-test course in electronics based on the CDIO framework for engineering education. *Inter. J. of Electrical Engng. Educ.*, 49, **4**, 349-364 (2012).

5. Pavlovskaya, I., Course *Introduction to Profession* as a part of CDIO approach implementation. *Proc. IEEE North West Russia Young Res. Electr. Electron. Engng. Conf.*, 28-29 (2014)
6. Marasco, E. and Behjat, L., Integrating creativity into elementary electrical engineering education using CDIO and project-based learning. *Proc. IEEE Inter. Conf. on Microelectronic Systems Educ.*, 44-47 (2013).
7. Zhang, Y., Application of CDIO project teaching method in automatic detection technology. *J. of Changzhou Vocational College of Infor. Technol.*, 10, 1, 54-56 (2011).
8. Alarcón, E., Bragós, R. and Sayrol, E., Learning to conceive, design, implement and operate circuits and system. *Proc. Inter. Symposium on Circuits and Systems*, 1183-1186 (2011).