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# Application of CDIO in practice and training of an engineering automation specialty

**Guohan Lin & Yongqi Tang**

Hunan Institute of Engineering
Xiangtan, Hunan, People's Republic of China

ABSTRACT: Aimed at the current shortages that exist in the practice and training of an engineering automation specialty in the undergraduate level courses in Chinese universities, the CDIO method (Conceive, Design, Implement, Operate) was applied to reform education and training. To optimise the outcomes, Conceive, Design, Implement, Operate was combined with project teaching. The teacher training, project design, training content and assessment have been at the core of the reform and are discussed in this article. It was found that the application of CDIO to training cultivated the student's practical ability, innovation and teamwork in a true project environment, and also improved the teachers' ability.

## INTRODUCTION

An automation specialty is closely related to electrical and electronics technology, control theory, signal detection and processing, bus technology, as well as computer network technology. The goal of it is to develop applied talent in motion control, process control, manufacturing system automation, instrumentation and automation equipment, robot control and intelligent monitoring systems.

The cultivation of application-oriented talent focuses on engineering education and follows the rapid development of engineering and technology. Practice courses, including electrical, electronic, production practice, engineering practice and training, and graduation design, are the main vehicles for the enhancement of engineering ability.

The engineering practice and training occurs at the end of undergraduate courses. Students are required to choose two or three actual projects, so as to allow their undertaking engineering projects that are as close as possible to reality. They will master the use of integrated, learned knowledge, so as to solve engineering problems, become familiar with typical automation technology and master the maintenance of actual systems.

The Electrical Automation Engineering Training Centre for Engineering Practice and Training at the Hunan Institute of Engineering was founded in 2000. Since the completion of the Training Centre, students have learned the principles of practical application systems and mastered the skills of debugging, fault analysis and troubleshooting. The teaching effect and quality generally have improved over time.

However, in recent years, some problems have emerged, such as training being divorced from the engineering industry. This is due to training equipment that is obsolete and not varied enough. To address this, as well as meet the demand for application-oriented talent and to comply with the *Excellent Engineer Education and Training Program* in China, the CDIO method (Conceive, Design, Implement, Operate) was introduced into the project teaching to explore and reform engineering teaching.

## CDIO ENGINEERING EDUCATION MODEL

The CDIO innovative and educational framework was formally launched in 2000 by the Massachusetts Institute of Technology and three Swedish universities: Chalmers University of Technology; Linköping University and the Royal Institute of Technology. It uses the entire lifecycle of a modern industrial product as a vehicle by which students improve their engineering ability in an active, practical and organic way [1]. The CDIO model has been widely applied to mechanical and electrical engineering programmes [2][3].

The CDIO syllabus has comprehensive, detailed goals for engineering education. The syllabus consists of four parts, as shown in Figure 1.

| 4. CDIO | | |
|---|---|---|
| 1. Technical knowledge and reasoning | 2. Personal and professional skills | 3. Interpersonal skills |

Figure 1: Structure of the CDIO syllabus.

The project teaching method takes a real engineering project and divides it into a series of teaching tasks, according to connections between knowledge required for the tasks. To develop the students' creative ability in solving practical problems, the teaching proceeds, from project to knowledge to problem to task.

Project teaching encourages students' enthusiasm and initiative. Teacher-centred learning changes to student-centred, textbook-centred learning changes to project-centred and classroom-centred learning changes to experience-centred. To some extent, the project teaching method was initiated by the CDIO method. The CDIO education philosophy emphasises that, through the implementation of a project, students can improve their overall abilities and acquire specific knowledge [4][5].

## REFORM OF AN ENGINEERING COURSE USING CDIO

### Guiding Principles and Goals

Engineering practice is important in cultivating the engineering ability of students studying an automation major. It can enable students to improve their innovative and engineering practice ability, as well as to enhance their understanding of the application of knowledge in the field of automation. Through building a bridge between theoretical knowledge and practical skills, CDIO enhances individual ability in various areas, i.e. electrical automation control systems, computer monitoring and control systems, automatic control system installation, debugging, operations and maintenance.

The CDIO engineering training concept was assimilated into the whole process of engineering training. The training was completed according to the CDIO syllabus requirements. The process was student-centred, but teacher-led. Students acquire knowledge by the *conceive-design-implement-operate* mantra of CDIO. Innovative ability and practical abilities can be improved, as is the ability to analyse and solve problems.

### Reform of the Teaching by Applying CDIO

Practical ability is at the core of CDIO. It starts with *what to do*, which is the vehicle leading to *learning to do* and *doing to learn* as the key approaches to learning. The reform of engineering training based on CDIO has the following aspects:

- Teacher requirements for CDIO:

  Twelve standards were put forward in the CDIO syllabus requirements. Among the 12 was *enhancement of faculty competence* and *enhancement of faculty teaching competence* related to teachers. Therefore, for this reform double-quality teachers were selected as instructors. All of the selected instructors have working experience or enterprise-funded projects, as required [6].

  The University also provides funds for teachers without working experience, to gain working experience; it strives to create conditions and make policies that encourage teachers to participate actively in engineering practice.

- Select appropriate training content:

  As the automation specialty has the characteristics of being multi-disciplinary, with a short knowledge update cycle, a suite of training devices were purchased. These devices include a DSP (digital signal processing) based variable frequency control system, magnetic levitation control system, complex process control system, dynamic data acquisition system, automated network test system, automated parking equipment control system, machining simulation and automatic line control system, central air conditioning automatic control systems, remote meter-reading system, field bus and industrial control network system and an industrial robotics training system.

  All of the aforementioned engineering training systems are comprehensive and modular, covering a wide range of automation applications. Furthermore, the devices are easy to disassemble, which enables students to learn the installation of hardware devices and to perform simple to complex training tasks. Guided by the needs of industry, teachers develop projects using these training systems. Some training projects directly draw from the enterprise-funded project, such as a dynamic data collection system and a networked automatic test system. These are based on the high-voltage electrical network group control integrated test system that won the second award for scientific advancement by Hunan Province. These projects help students to be directly involved in the development process of enterprise projects.

Each of the above training systems was divided into multiple sub-tasks. Take the motion control training system as an example. The system can be divided into hardware installation and wiring, program design and system debugging, troubleshooting, test operating parameters.

The required knowledge related to this system includes power electronics, variable-frequency drive technology, PLC control technology, touch screens, stepper motors, DC motors, asynchronous motors and industrial network communication technology. The specific training content of a motion control system is listed in Table 1.

Table 1: Training tasks and sub-tasks for the motion control system.

| Task | Sub-task |
|---|---|
| 1 | 1.1 Three-phase asynchronous motor drive; self-locking control and Jog control; direct launch control<br>1.2 Three-phase asynchronous motor Y-Δ reduced voltage starting control<br>1.3 Three-phase asynchronous motor interlock reversing interlock control |
| 2 | 2.1 OLC based three-phase asynchronous motor interlock reversing interlock control<br>2.2 PLC based three-phase asynchronous motor Y-Δ reduced voltage starting control |
| 3 | 3.1 Parameter setting and operation of inverter<br>3.2 Inverter based forward/reverse motor control<br>3.3 Inverter-based multi-section-speed selection control |
| 4 | 4.1 PLC control of the external terminals of the inverter forward/reverse control<br>4.2 PLC-based digital multi-speed control |
| 5 | 5.1 Principles of the encoder<br>5.2 Measuring speed and position with a quadrature encoder |
| 6 | 6.1 PLC Communication instruction<br>6.2 Open-loop speed control based on PLC communication |
| 7 | 7.1 Position control based on close-loop speed control using PLC communication<br>7.2 Close-loop speed control based on PLC communication |
| 8 | Touch screen configuration control based on closed-loop positioning |
| 9 | Communication between PLC and inverter |

- Design the training according to the CDIO relevance principle:

  During training, the system, including principles, project ideas, system operation, system evaluation, product design and parts arrangement were first explained by the instructor. The students, then, undertook system operational training, troubleshooting, performance parameter testing and inspection. Finally, a training design was produced. The first step was focused on the improvement of the required level of expertise, the second step emphasised operational training and skills development and the third step laid particular stress on engineering ability. The engineering training flow chart is shown in Figure 2.

- Adopt process assessment to follow the CDIO evaluation principles:

  In traditional assessment, the assessment indicators mainly consist of attendance, quality and defence of the report. This makes it difficult to fully evaluate the students. As the CDIO educational model emphasises capacity-building, the evaluation also focuses on capacity assessment.

  In the assessment of engineering practice and training, the assessment indicators were further sub-divided into panel discussions, attitude and responsibility, nature of the project, use of development tools, communication skills, task completion rate, open thinking and innovation. Besides the teacher and engineers, the students are also involved in assessment, i.e. self-evaluation and peer evaluation in and between groups. This assessment method better reflects the practical training situation of the students; it fully and objectively evaluates the students in accordance with the CDIO principles.

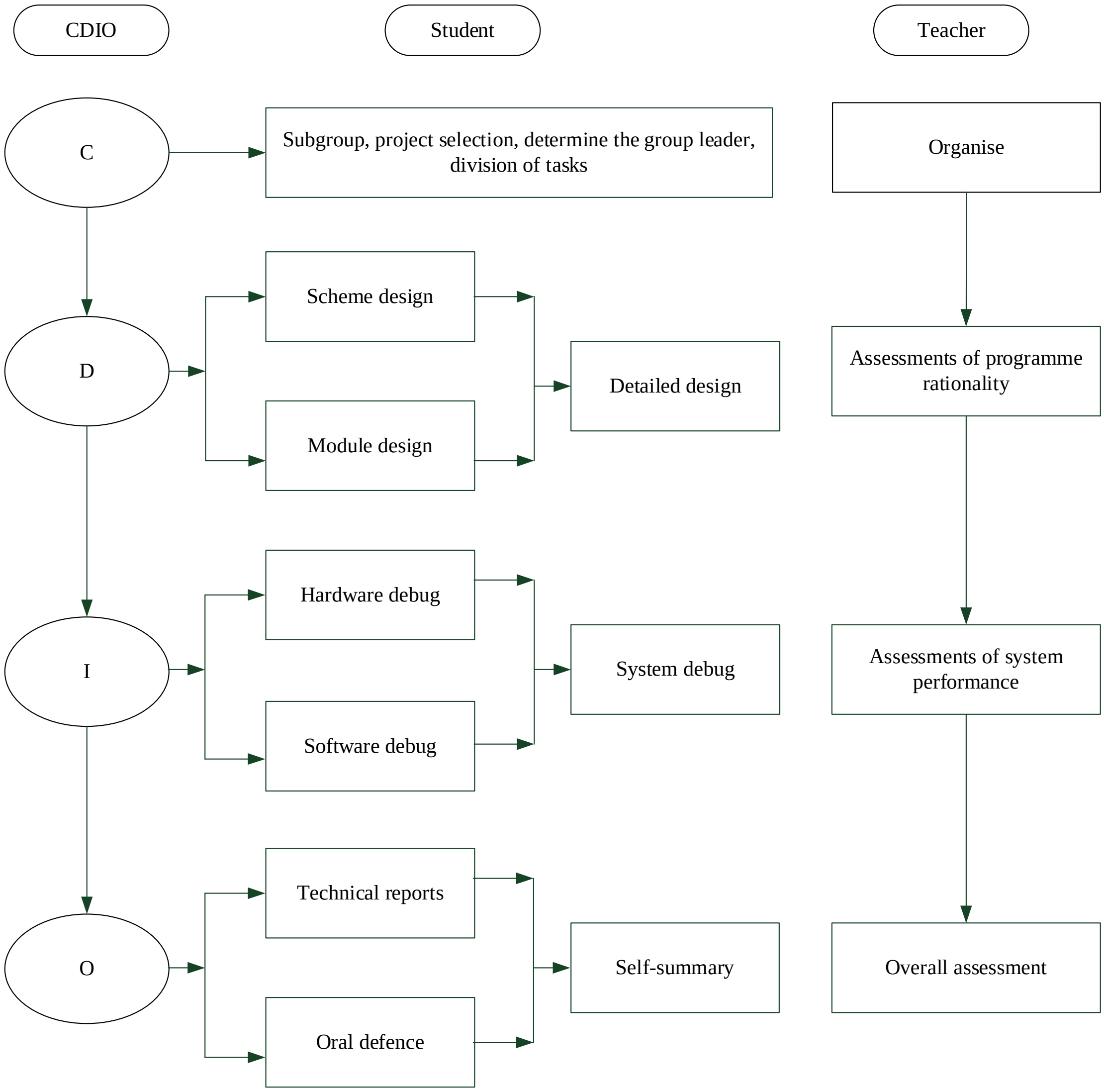


Figure 2: Flowchart of engineering training.

## CONCLUSIONS

Automation specialty is characterised by an emphasis on practice. With engineering ability at the core, the Conceive, Design, Implement, Operate mode of engineering education was introduced into the training of automation major students. The development of appropriate teachers, the design of the training, the training process and assessment were discussed.

Experience has shown that the CDIO approach generated enthusiasm and inspired the initiative of students. A student receiving an engineer's training in an actual engineering environment lays a good foundation for graduation design. It was also found that the students' self-learning, team spirit, professional skills and practical vocational skills were improved.

## ACKNOWLEDGMENTS

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## REFERENCES

1. Dai, B., Ji, W.G., Liu, J.G. and Zhang, L.X., Research and practice on cultivating engineering ability- oriented students with a major in automation. *Proc. 8th Inter. CDIO Conf.*, Brisbane, Australia (2012).
2. Armstrong, P., Kee, R., Kenny, R. and Cunningham, G., The development of a capstone project course based on CDIO principles. *World Trans. on Engng. and Technol. Educ.*, 5, **2**, 299-302 (2006).
3. Cao, W., Liu, Z. and Zheng, L., Reforming the teaching of a single chip microprocessor course based on CDIO engineering education. *World Trans. on Engng. and Technol. Educ.*, 11, **4**, 428-433 (2013).
4. Marasco, E. and Behjat, L., Integrating creativity into elementary electrical engineering education using CDIO and project-based learning. *Proc. 2013 IEEE Inter. Conf. on Microelectronic Systems Educ.*, TX, Austin, USA, 44-47 (2013).

5. Norrman, C., Bienkowska, D., Moberg, M. and Frankelius, P., Innovative methods for entrepreneurship and leadership teaching in CDIO-based engineering education. *Proc. 10th Inter. CDIO Conf.*, Barcelona, Spain, (2014).
6. CDIO. The CDIO syllabus in topical form (2008), 2 May 2008, http://www.cdio.org/cdio_syllabus_rept/cdio_syll_complete.html.