Application and management of EPI-CDIO teaching for engineering students in local undergraduate colleges

Cuibi Yang†, Shuliang Huan‡ & Yong Yang†‡

Chongqing Three Gorges University, Chongqing, People's Republic of China†
Southwest Jiaotong University, Sichuan, People's Republic of China‡

ABSTRACT: The EPI-CDIO (Ethics, Professionalism, Integrity - Conceive, Design, Implement, Operate) teaching applied to engineering majors at local undergraduate colleges in China is a new, innovative educational concept. It not only values practice and application, it also makes up for the lack of instruction in professionalism, as well as ethical and professional integrity in higher engineering education. Presented in this article is an outline of EPI-CDIO training programmes and the teaching evaluation management systems, including the use of doubly qualified teacher teams. Special attention is paid to the cultivation of engineering students' humanistic quality in addition to fostering a solid professional foundation, strong project development, design, construction and engineering innovation ability. The results have been praised by teachers and students and have achieved good effects.

INTRODUCTION

Research and surveys on the employability of engineering students from such disciplines as architecture, mechanics and electronics reveal the qualities most important in 2015 to gain employment in China. Of course, special attention must be paid to professional skills and learning. However, society and enterprises attach great importance to the moral character, teamwork, and the executive and innovative abilities of prospective employees; but, these qualities largely are ignored in students' learning [1].

A research report by Mc Kinsey Global Institute on employment said there is less than 10% of about 600,000 Chinese engineering students and personnel who are suitable for international companies [2]. It opines that the engineering talent cultivated in colleges and universities in China does not meet the needs of society. Therefore, how to foster and train engineering students in colleges has become an urgent problem for undergraduate engineering majors. The EPI-CDIO (Ethics, Professionalism, Integrity - Conceive, Design, Implement, Operate) methodology applied in reforming engineering education can solve the basic problem in engineering education.

EPI–CDIO TEACHING MODE

The CDIO system arose from international research by the Massachusetts Institute of Technology (MIT) and three other universities, viz. Charles Moss Industrial University, Linkoping University and the Royal College of Engineering in Sweden. At the beginning of 2000, after four years of research and exploration, the Knut and Alice Wallenberg Foundation provided $US20 million, to develop the CDIO engineering education concept and establish an international organisation named CDIO [3]. Since 2004, CDIO has spread to 29 countries and 92 colleges and universities around the world [4]. It emphasises that engineering education should occur in an enterprise and its social environment.

Conceive, Design, Implement, Operate stresses a product's life cycle, from research to operation. This encourages engineering students to take the initiative in solving practical problems, and highlights organic connections between what is taught on a course, and actual engineering technology and skills. Moreover, CDIO attaches great importance to quality management, as well as emphasising project management, process and operational management.

Ethics, Professionalism, Integrity, or EPI, is an extension to CDIO for engineering education developed by Shantou University in China [5]. Therefore, EPI-CDIO is a new mode of higher engineering education, which combines ethical, professional behaviour of high integrity (EPI) with the CDIO lifecycle approach. The aim is to train Chinese engineers to international standards. It is a new, innovative engineering teaching mode that makes up for the lack of occupational and practical ethical aspects in higher engineering education in China. Value is placed on doing the work of an engineer and doing it well. But, a student's humanistic qualities are also to be cultivated. What is important is for an engineering

professional to have a strong sense of professional ethics and responsibility, powerful team spirit, good interpersonal communication skills and an expressive ability in foreign languages [6].

NECESSITY FOR IMPLEMENTING EPI-CDIO TEACHING FOR ENGINEERING MAJORS IN LOCAL UNDERGRADUATE COLLEGES

China urgently needs a large number of engineers of international standard to be cultivated in local undergraduate colleges. However, there are still many problems with engineering education in China. Specific problems are discussed below.

Theory Valued Over Practice

The phenomenon that theory is valued but practice neglected is a common feature of engineering majors. Most teachers in higher education attach importance to theory over practice and the time spent on projects and the practices of enterprises is inadequate. So, the time spent on the theoretical components of the course is much larger than the time spent on the practical course components. Table 1 shows an example of the relative weighting of theory and practice for 2015, from the undergraduate training programme of the Mechanical Design Manufacture and Automation major at Chongqing Three Gorges University.

Table 1: Timetable for the theoretical and practical coursework in each semester. The time unit is one week.

First semester			Second semester			Third semester		
Classroom teaching	Centralised practice	Review test	Classroom teaching	Centralised practice	Review test	Classroom teaching	Centralised practice	Review test
14 weeks	3	2	16	12	2	15	3	2
Fourth semester			Fifth semester			Sixth semester		
Classroom teaching	Centralised practice	Review test	Classroom teaching	Centralised practice	Review test	Classroom teaching	Centralised practice	Review test
17 weeks	1	2	15	3	2	15	3	2
Seventh semester			Eighth semester					
Classroom teaching	Centralised practice	Review test	Classroom teaching	Centralised practice	Review test			
10 weeks	12	2	0	10	0			

Notes:

- Chongqing Three Gorges University is located in Wanzhou, Chongqing, China. It is the only undergraduate college in the Three Gorges Reservoir Area.
- Centralised practice refers to military training or foundation education in the first three weeks of the first semester.
- There are 19 weeks in the first semester and 20 weeks in semesters three through six.
- Students go on their first internship at the end of the second semester lasting over the summer vacation. Hence, the second semester is more than 20 weeks.
- Students go on their second internship from the summer holiday at the end of the sixth semester to the middle of the seventh semester. Hence, the seventh semester is more than 20 weeks.
- Graduation design and reply are usually arranged in the eighth semester. The rest of the time is under the control of the students, such as participating in recruitment and finishing the formalities of the graduation procedures.

Table 1 shows that from semester one to six, the time spent on centralised practice accounts for 16%, 40%, 15%, 5%, 15% and 15%, respectively of the total class time. By comparison, the time used for classroom teaching accounts for 74%, 53%, 75%, 85%, 75% and 5%, respectively of total class time. So, the time used for centralised practice is much smaller than that used for classroom teaching. In the seventh semester, the time used for centralised practice accounts for half of the time, while in the eighth, all the time is used for centralised practice.

In conclusion, students do not completely take part in social practice, from admission to the end of sixth semester. Also, the time spent on classroom teaching is much more than that spent on centralised practice in the first-to-sixth semesters. From the first to the eighth semester, the time used spent on centralised practice accounts for 29% of the total class time and the time spent on classroom teaching accounts for 63% of the total. So, the latter is more than twice as much as that the former. During the four years in college, practice mainly occurs in the seventh and eighth semesters. Therefore, practice and theoretical knowledge are separated and not closely integrated.

Teacher Team Structure and the Need for Doubly Qualified Teachers

In some engineering majors, most teachers with high academic and professional standing have rich theoretical knowledge and pay close attention to the subject knowledge. However, they are poor in engineering background

knowledge of enterprises and companies; thus, lacking practical ability and communication skills. In addition, universities and colleges place emphasis on scientific research, which forms an important part in assessing teachers for promotion. Therefore, most teachers attach importance to theoretical teaching and do not have enough time to carry out practical teaching or to support students in gaining practical experience at factories or companies.

Students weak in practical ability and communication skills are out of line with the requirements of society. When local undergraduate colleges are transformed to applied technology universities, the teacher teams of engineering professions must be changed, in particular, including the incorporation of doubly qualified teachers, who have not only rich engineering education theory, but also practical engineering backgrounds and experience.

Teaching Quality and Evaluation

The assessment of students is out-of-date and lacks scientific precision and objectivity. At present, students in some engineering majors are evaluated only on theoretical knowledge gained in classroom teaching and not by students' practical abilities gained in enterprises. The evaluation of students is by teachers' unilateral evaluation and does not involve the students' self-evaluation or peer evaluation by other students. So, in evaluation, most teachers ignore the integration of practice and theory. The student's assessment is the final score in a theoretical test and does not include a practical assessment and practical examination.

The colleges and universities value scientific research, which detracts from the time teachers spend in managing teaching quality; and yet more attention is needed. In most engineering majors, the evaluation does not cover the CDIO process of conception, design, implementation and operation, nor does it assess EPI, i.e. ethics, professionalism and integrity. Assessment indices are non-specific and are generalised results. Hence, students do not seriously address practice in their studies and teachers do not know whether the students are actually *fit-for-purpose*.

EPI-CDIO TEACHING FOR ENGINEERING STUDENTS IN LOCAL UNDERGRADUATE COLLEGES

Compared with Project 985 and Project 211 students (i.e. develop world-class universities in China and establish key national universities and colleges in China, respectively), local undergraduate college students' quality is not high and the variation among students is large. So, it is highly important for the teachers to train and teach the students in accordance with their abilities.

An EPI-CDIO Training Programme

Cultivating personnel with practical ability is the goal of the training programmes of engineering majors in local undergraduate colleges. Practice and application is the core and focal point of training programmes for engineering professionals in the applied undergraduate colleges. The quantity and quality of centralised practice in colleges and scattered practice outside of colleges needs to be improved. In the training programme, practice should be at least equal in quantity to theoretical classes or even a ratio between practice and theory of 6:4. Engineering teachers should apply immediately what the students learn in class to the control processes of integrated systems, so as to include the conceive, design, implement and operate function, to mirror the content of EPI-CDIO training. Students need to be trained in practical operations and innovative ability, as well as interpersonal communications and teamwork ability.

The quality of engineering education is reflected in the teaching and supervision. Teachers in the engineering majors should have not only rich theoretical knowledge, but also strong engineering technical abilities. Teaching practice and supervision should be strengthened. Teachers should be the designers of the classroom teaching and the supervisors and assessors of the teaching. Theoretical teaching and experimental practice should be deeply integrated and practical training valued [7].

Currently, in view of the situation, where practice and theoretical teaching are separate, the practice teaching should be organised into the four courses - conceive, design, implement and operate for EPI-CDIO teaching in local undergraduate colleges. The freshmen should know that the engineering education course combines theory with practice. This makes students learn about the relationship between the engineering profession and industry, and the advantages of studying through continuous practice to enhance their autonomous learning ability in the future.

Doubly Qualified Teachers for EPI-CDIO Teaching

The teacher is the key factor in cultivating applied and innovative talent in the new mode of EPI-CDIO engineering education. First, the strategy of *going out and please come in* is implemented to train doubly qualified teachers. In this strategy, the lack of engineering experience and engineering ability among engineering teachers is corrected by encouraging teachers to go out into factories, workshop, enterprises, and the marketplace for practical operational training and experience. Hence, they come to combine theory with practice as real, practical engineers.

Engineers and technical experts, from enterprises and factories, and who have strong operational ability, should be introduced into local undergraduate colleges and help in the teaching of engineering students. A double tutorial system

teachers' team should be constructed. Many professional teachers lack practical experience in companies and enterprises. Therefore, engineers with practical engineering experience in companies and enterprises should be employed to hold external tutorials, as members in the engineering teaching team. The external tutorials will have responsibility for individual students. From the beginning of the first year, they will build a student project team and guide the practical projects of undergraduate students, which will be supported by internal tutorials provided by teachers from the colleges. Each student in a project team will take turns to be in charge of the team, which cultivates organisational, co-ordination and management abilities. The tutorials establish team files and the project fosters the students' EPI-CDIO abilities.

Teaching Evaluation for EIP-CDIO

The assessment of students is not only an important indicator of measuring specific student-learning outcomes, it is also an important means by which to test the teaching of the teachers. Hence, it provides an important feedback loop in the teaching quality control system. The traditional assessment system for engineering education must be changed when EPI-CDIO is implemented.

First of all, students' quality management indicators should be diversified and process management indicators should be strengthened. The EPI-CDIO teaching pays special attention to the integrated processes for controlling to production of products. But, it also cultivates students' interpersonal skills and fosters the students' professional ethics and integrity. These need to be in the curriculum content and be part of the study process and part of the evaluation. This breaks away the single evaluation model used before for evaluation. Therefore, apart from the traditional theoretical written and oral tests, students need to be evaluated on operational ability, product design, writing product design specifications, product evaluation, testing, and so forth. The evaluation should include peer- and self-assessment.

Second, the teaching quality management of engineering teachers should be precise and objective, with the aim of improving the students' practice ability. The traditional method, which is to use the level and the number of research papers for teachers' evaluation and job promotion, should be changed in local undergraduate colleges. Engineering teachers need to pay special attention to teaching ability and engineering practice ability, including product design, process and system control. Other important student outcomes include project management, team co-operation, interpersonal communications and lifelong learning ability. These factors should stimulate teacher enthusiasm for the teaching and improve teaching quality.

CONCLUSIONS

The Ethics, Professionalism, Integrity - Conceive, Design, Implement, Operate (EPI-CDIO) engineering teaching applied in the engineering majors of local undergraduate colleges is a new, innovative educational concept, which compensates for the lack of occupational and practical aspects in higher engineering education in China. To strengthen the construction of engineering majors of local undergraduate colleges, an EPI-CDIO professional personnel training programme was formulated.

The effective teaching evaluation management system is determined, including a doubly qualified teachers' team. The colleges and universities should ensure that the engineering professionals have solid professional foundations with strong project development, design, construction and engineering innovation ability. In addition, special attention should be paid to the cultivation of students' humanistic qualities. The EPI-CDIO teaching has been praised by teachers and students and has had good effects.

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