Application of a CDIO-based practical teaching system in an architecture major

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ABSTRACT: The Conceive - Design - Implement - Operate (CDIO) model is a new practical teaching concept. It combines theory and practice, and emphasises the cultivation of students' basic theoretical knowledge, as well as strengthening their innovative and team collaborative abilities. Taking one architecture course as an example, a CDIO-based practical teaching model was created. It includes course outline, learning organisation, teachers' teaching management and students' assessments. Rough theory was used for uncertainty analysis, both on the traditional and CDIO teaching, to demonstrate the effectiveness of the CDIO model. In practical teaching, the subjectivity required is combined with objectivity, which is beneficial in improving students' abilities.

INTRODUCTION

Architecture is a discipline covering engineering, technology and art, and has been much emphasised in recent years in China, given the rapid development of urban and rural areas [1]. The architecture major at Chang'an University includes building, urban and indoor design. The major components include *architecture*, *building design and principle*, *Chinese and foreign architectural history*, *building structures and building mechanics*. The course is teacher-dominated, with a lack of innovative and practical activities. This is not conducive to improving students' comprehension and so a better teaching system is required [2].

Conceive - Design - Implement - Operate (CDIO) is a teaching model developed over four years, from 2000, by four universities, including MIT [3]. *Conceive* includes customer requirements, required technology, enterprise strategy, system design, development concepts, technical requirements and business plans. *Design* includes engineering plans and drawings, as well as the implementation plan. *Implement* refers to the process of converting the design plan into products, including manufacturing, test and confirmation. *Operate* includes the evaluation of the product, modifications and improvements [4]. Conceive - Design - Implement - Operate combines theoretical and practical project knowledge to improve students' theoretical and innovative abilities [5].

At present, there are more than 30 well-known universities in the world actively promoting CDIO. But the use of CDIO in China is still at an initial stage and needs practical verification. Also, there is a lack of underpinning theoretical research [6].

This article reports on the use of mathematical modelling for case verification and uncertainty analysis; it compares CDIO teaching with traditional teaching to determine the effectiveness of CDIO teaching. This provides a basis for universities in China to promote CDIO, and could promote further research on the use of CDIO.

APPLICATION OF THE CONCEIVE - DESIGN - IMPLEMENT - OPERATE MODEL IN THE PRACTICAL TEACHING OF ARCHITECTURE

A significant characteristic of the CDIO education model is that it combines university education with engineering practice. It cultivates students' basic engineering theory and innovative ability to help produce a new generation of professional engineers.

The CDIO engineering education model can effectively establish an interactive, explorative learning mode that guides students to raise questions and solve problems. The teaching reform of the practical teaching should still reflect the traditional theoretical knowledge of the course, but also comply with the CDIO requirements.

The teaching method reform based on the CDIO model, has the following characteristics:

- Create a course plan; create a good teaching environment; adopt a teaching method reflecting students' abilities; cultivate students' interest in learning.

- Make use of the practical training capabilities of applied undergraduate colleges. Introduce practical projects into the course teaching and cover student groups, project plans, system feasibility, system design, detailed process design, testing, modifications and enhancements.

- Students should master project development and management through the situational teaching model. This will improve students' problem-solving and team co-ordination abilities.

- Adopt the CDIO project-driven teaching mode; introduce situational teaching and interactive teaching to make students actively and effectively participate in the course learning. Conceive - Design - Implement - Operate is a new, recognised education model for engineering courses in universities. It combines theory with practice using a *project case-study*.

The project-driven teaching method requires the incorporation of teaching content into each project. Project tasks make students raise questions which they, then, solve through independent thinking and the guidance of the teachers. Therefore, it cultivates a student's independent learning, innovative thinking, as well as the ability to discover and solve problems. The following actions are required:

- Establish and improve the CDIO project library. Improve students' knowledge of CDIO. The CDIO project library should emphasise engineering application quality, and link experiment to design and learning.

- Construct a hierarchical, staged and graduated practical teaching system.

- Establish the course credits and pay attention to the course assessment. Include a good proportion of theory and practical teaching, to cultivate students' practical and innovative abilities.

- Construct a good platform for CDIO practical learning and emphasise industry links to the learning. By project case and practical training, CDIO can assist students to learn in an actual project situation and apply knowledge to actual problems. Thus, this avoids the disadvantage of traditional teaching methods dominated by theory. Practical teaching plays to the potential abilities of students according to aptitude, and so puts their talents to good use.

CONCEIVE - DESIGN - IMPLEMENT - OPERATE- BASED PRACTICAL TEACHING OF AN ARCHITECTURE MAJOR

Taking the core course *Architecture* of a university as an example, the traditional teaching method was compared with a CDIO-based practical teaching model to further analyse and research the CDIO model.

Course Reform of an Architecture Major

Adopting a Conceive - Design - Implement - Operate-based practical teaching approach means a reform of the professor-dominated theoretical guidance into the student-dominated practical orientation, i.e. to transform it into a student-dominated teaching model, that emphasises the students' independent learning and practical ability (see Figure 1 below).
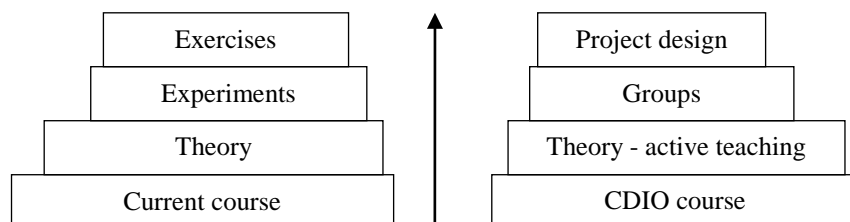

Figure 1: Comparison between the existing course and a course with the CDIO model.

Learning Under the CDIO Model

In groups, and driven by the project design, under the guidance of teachers students continuously discover and raise questions related to the project, which strengthens their learning. They collect information through various channels,

such as the Internet, books and newspapers and by surveying buildings *in situ*. They develop designs, carry out practical tests, identify defects and summarise their design experience to further deepen their knowledge and practical application ability.

- *Groups:* formed groups create an efficient learning organisation model. A group of two-to-three students communicate and exchange information about the project or experiment and provide mutual help. A division of labour is agreed, with different students responsible for different parts of the project.

  Project team: it creates the environment where the best design and implementation is achieved through mutual co-operation and communication. Therefore, this is a good approach to improving students' communication and co-operative abilities, which is an important objective of the CDIO practical teaching model.

- *Teacher management:* train the teachers about the Conceive - Design - Implement - Operate model. Provide more teachers with the opportunity to learn in enterprises, and carry out *ad hoc* research. Engage senior engineering personnel in the project design.

- *Teaching management:* in the process of teaching, combine theory with practice. The students are required to learn a*ctivel*y based on problems encountered in practice, guided by the teachers. After the teacher introduces the project and explains the key points, the student completes the learning out of class.

- *The teacher guides different groups:* for example, by advising on which methods to use and how to approach problem solving. In addition, students may be provided with some approaches for independent learning, for example, set up a student communication platform; set up a teacher teaching platform; provide relevant learning materials; and encourage a good discussion environment among the group.

- *Assessment form:* the traditional teaching assessment method is usually a theoretical examination plus a practical score, in which the theory accounts for 80% and the practical 20%. Therefore, the traditional teaching method can cause the student to emphasise theory while ignoring practice.

The CIDO-based practical teaching model aims to cultivate ability where *ability = theory + practice + effect*. This provides a relatively scientific assessment method. The specific form of the assessment for this course is shown in Table 1.

Table 1: Assessment contents of CDIO-based practical teaching.

Assessment contents	Proportion %	Key assessment objective	Method of assessment	Remarks
Project design	40%	Knowledge application, scientific and reasonable design	Report, display board and theoretical examination	Defence of the design to determine originality
Group design process	20%	Project creation, design, implementation and team collaboration	Intermediate processes or records dealing with conceiving, design and improvement of the project	Teachers may set random examinations and observe the records
Report summary	15%	Cultivation of individual ability and quality of learning	Report summary and analysis	
Overall project evaluation	25%	Team collaboration, communication and information exchange and use of knowledge to solve problems	Defence of the project	Teacher may raise problems or organise a project defence

This assessment method imposes high requirements on both students and teachers. For students, it is impossible to pass the examination only by cramming. Meanwhile, the teachers are required to strengthen their contact with students, better understand the students' learning and to make and maintain a variety of records, as well as carrying out a variety of evaluations.

ANALYSIS OF THE EFFECT OF CDIO TEACHING

Analysis of the effect of CDIO teaching: an architecture class was used by which to analyse the practical effect of the CDIO model, by contrasting it to the original teaching mode. The aspects investigated were the learning interest; independent learning ability; communication ability; team co-ordination; problem-solving and knowledge mastery. Ten groups were selected for uncertainty analysis by which to ensure the veracity of the results. The results are shown in Figure 2, where the lighter bars are for CDIO and the darker bars are for the original teaching mode.
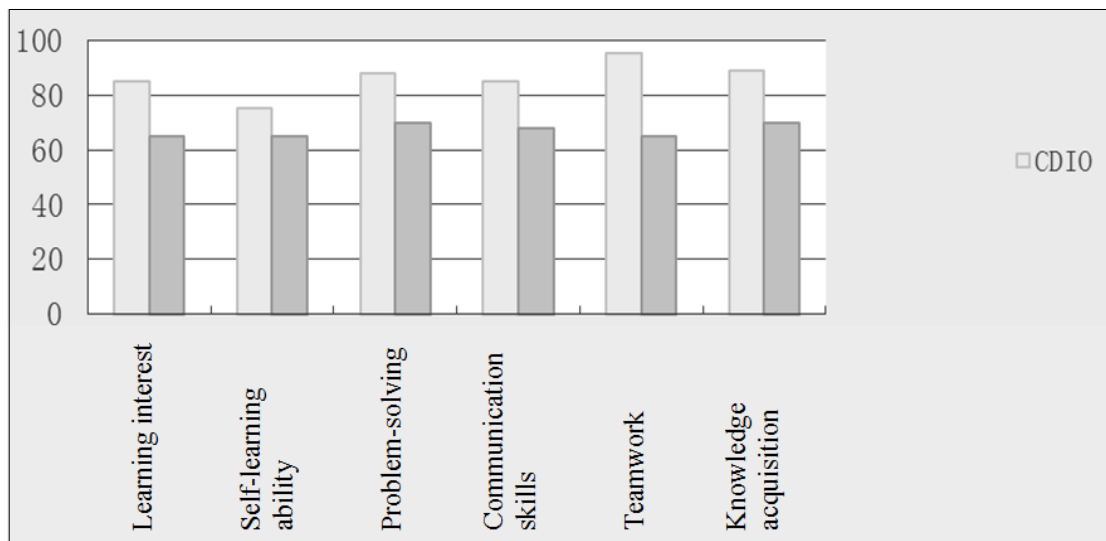

Figure 2: Conceive - Design - Implement - Operate teaching effectiveness compared with traditional teaching.

According to the results of the analysis, CDIO teaching requires high team collaboration and knowledge mastery; it is beneficial in improving students' interest in learning, communication ability and problem-solving ability. Conceive - Design - Implement - Operate yields only one weak improvement, which is independent learning ability. Therefore, it can be concluded that students support teaching in the CDIO model; especially, there are improvements in communication ability, as well as innovative and problem-solving ability. In addition, it is found that this teaching method can strengthen communication among students and can also mobilise the female students' interest in architecture.

CONCLUSIONS

Implementing the CDIO model of practical teaching is not complicated, and is an innovative model for engineering and science education within universities. Specifically, it was used to establish a reasonable and complete teaching system for architecture design. By improving the knowledge and learning ability of students, society's requirements for professional architectural talent with manufacturing technology skills can be better met.

The basic principles of CDIO are fairly simple, with wide application, and can be adopted for the teaching of most courses of architecture. As shown in this article, compared with the traditional teaching form, the CDIO practical teaching model is effective in the teaching of it and the cultivation of the abilities of students majoring in architecture. So not only is the course reformed but the overall teaching system is improved. Therefore, to achieve the best benefit, the CDIO model should be implemented, taking account of the available human and other resources.

REFERENCES

1. Lin, J., Explore the greenization construction of urban architectural engineering. *Urbanism and Architecture*, **2**, 64-65 (2014).
2. Utaberta, N., Hassanpour, B., Bahar, M.A. and Ani, A.I.C., A comprehensive learning of architecture education: understanding critique session as learning process and criteria-based assessment in the architecture design studio. *Procedia - Social and Behavioral Sciences,* 102, **2013**, 21-32 (2013).
3. Berggren, K.F., Brodeur, D., Crawley, E.F., Ingemarsson, I., Litant, W.T.G., Malmqvist, J. and Ostlulnd, S., CDIO: an international initiative for reforming engineering education. *World Trans. on Engng. and Technol. Educ.*, 2, **1**, 49-52 (2003).
4. Wang, S. and Hong, C., CDIO: the Classic mode of engineering education in MIT - an unscrambling on the CDIO syllabus. *J. of Higher Educ. in Science & Technol.*, 28, **4**, 116-119 (2009).
5. Xu, B. and Sun, H., Construction and practice of T-CDIO course system. *Research in Higher Educ. of Engng.*, **2**, 35-38 (2009).
6. Bai, J., Hu, L., Li, Y., Tian, Z., Xie, L., Wang, L., Zhou, M., Guan, J. and Xie, H., The progress of CDIO engineering education reform in several China universities: a review. *Procedia - Social and Behavioral Sciences*, 93, **2013**, 381-385 (2013).