A Design-Directed "Architectural Design" Course for Civil Engineering CDIO Program

Yingzi Wang
College of Engineering, Shantou University

Yunping Yang
College of Engineering, Shantou University

Xiaohua Lu
College of Engineering, Shantou University

Guangjing Xiong
College of Engineering, Shantou University

ABSTRACT
In year 2005, College of Engineering at Shantou University adopted the CDIO Initiative. Based on the CDIO education framework, a syllabus for "Architecture Design" course that is opened to sophomore has been drawn to replace the old one of "Building Construction". The CDIO competencies are incorporated into the course conduct. Except the classroom teaching, as another important part, an assignment is reformed from previous individual design-task to a teamwork-design. It is processed in a way of proposal – discussion– design through both of teamwork and the class activities. When finds problem, amending design after discussion are required till to reach the task's goal. The implementation process for this reformed Design-Directed Course is stated in the paper first. And then, the changes that of the new course transformed by CDIO approach are given. The impact of the practice to the ability, knowledge and personality are analysed by looking at the students' work and progress. After the first run of the course, the achievements and flaws of the course are studied and the future improvements are proposed in this writing as well.

KEYWORDS
Civil Engineering, course transform, CDIO, Architectural Design,

INTRODUCTION

Since year 2008, a design-directed "Architectural Design" course for Civil Engineering Program has been built to replace its predecessor of "Building Construction". Cultivating CDIO [1] competencies based undergraduate students is the main target of the course study. This course was implemented by the 2006 intake class first. According to the "Ability interrelated EIP-CDIO Mode" [2] set by Shantou University, a new course syllabus which is not only focused on the learning technical knowledge, but also for developing the student's personal and interpersonal competencies was issued to follow CDIO ideas.

COMPREHENSIVE COURSE TRANSFORM BY CDIO APPROCH

Changes

As a comparison between previous course of "Building Construction" and the reformed one of "Architectural Design", it can be seen in table 1 that significant changes on curriculum objectives, teaching content and method, as well as the assessment standard are made after the CDIO education framework introduced into the course.

Table 1
Comparison between the course that before and after be transformed

	before	after

Course Objectives	guide students to understand the functions of various components of buildings and learn the design methods of building construction	a) understand the functions of various components of buildings; b) practice the process of whole architectural design; c) Develop CDIO competencies with special attentions on self-learning, team-study and C-D-I-O in social environment.
Course Contents	a) Knowledge, including principle of architecture, basic knowledge of design and civil construction ; b) Construction design, complete the plans, elevations and details of a given building.	a) Basic knowledge of architecture and construction design, civil projects with the social and natural environment element and Energy-saving building design; b) An extension knowledge, series of engineering problems that for the design with a special emphasize on the sustainable civil engineering. c) Team-based architectural design project.
Methods	a) Basic knowledge part was accomplished through the classroom teachings up to 48 hours b) A joint construction design practice for a week.	a) Basic knowledge part was accomplished through the classroom lecturing and self learning for 24 hours in a total duration of six weeks. b) The extension knowledge part was accomplished in 6 hours in three weeks. Students needed to perform self learning and team-learning through classroom discussions. c) Team-based architectural design project lasting the whole semester. Students needed to refer back to their conceptual designs in the cornerstone project performed in the last semester, and modified their preliminary architectural designs according to new knowledge learnt in this course with an emphases on environment protection and resource saving.
Assessment	a) examinations b) level of the Building structure design	Assess to the whole CDIO process. The object of evaluation includes: a) research reports b) discussions record of improving the design c) examination of architecture knowledge d) level of the architecture design e) Performance and summary
Score criteria	Score of the exam (80%) + Design (20%)	Process of team-work (30%) + Score of the exam (20%) + Outcome of design and show (50%)

The Projects

To stimulate the interests and creativity of students, we selected "Residence", the most fundamental and substantial building type as a design object. The projects are identified in table 2. Each project has clear design topics and practical engineering conditions. The students were allowed to choose a work freely.

Table 2
"Project" to be chose

	Project topics	Design Topics
1	"Green city" residence	the residence with a good ecological environment and landscape
2	“Harmonious " residence	the residence meet the needs of different social strata to live together
3	"Adaptive" residence	the residence solving the multi-generational co-live and the residential population change
4	“Economical” residence	the residence For the urban low-income home
5	"Green practice" residence	Energy saving house

Repeatedly CDIO Process

The students were divided into fourteen groups (three in each group) and went through two entire CDIO cycles. The first cycle was to set up a profile for the building. The second one was to work out the detail design. The characteristics of each stage are stated in the below:

Conceive stage

In this stage, the students took all possible ways of being carried out in-classroom and out of classroom, including literature study, website search, discussion, consulting available experts, to build up a basic concept for the project. At meantime, teachers joined the seminar to ensure that the idea proposed by student is reasonable.

Design stage

Under the teachers’ guidance of as to answer any related questions and monitor progress, the students conducted their design work through the case study, discussion, debate, task analysis and drawing.

Implement stage

Within a short course study period, it seems impossible that students to complete a whole building construction process that is from design to put into use. Therefore in this stage, the implement effects of the design work were estimated by means of “experts”, “public” and “owners”. In which each team displayed their design work, when the rest teams took the role of “public” to evaluate the acceptance of the building and give their comments. Teachers acted as the “experts” to check whether the design is reasonable and in accordance with the national norms. At the same time, the teachers and students were also supposed to be the owner of a designed building to valuate if the work meets their requirements.

Operation stage

When a team was displaying their work, they also had to defend, debate or maybe take the criticism commented by the rest in the class. After the evaluation, each team had to revise their design according to the comments given during defence. Thus, the design work had been improved in the operation stage.

THE TRSFORM’S EFFECTS

Taking the results from questionnaire survey to combine with the observation made by the teachers and the outcomes got during the course study, it can be seen that some effects were produced after the course has been transformed from previous one.

Active attitude to learn

To accomplish an architectural design work, it involves many aspects of related knowledge, With a reception-learning method taken in “before transform”, students could hardly understand and apply the principles for their design task. But as a big benefit from the course transformation, it can be seen on the data given in table 3 which students evaluated

themselves, the interesting in course-study accounted for 70% high, much more than before. Meanwhile, the reformed teaching method including the new-designed C-D-I-O learning procedure has also been widely acknowledged by the students.

Table 3
Students' self-evaluation data after "Architectural Design" course study

Item / Grade	Interest in leaning	Practical Ability	Communicative competence	creativity	Self-study	knowledge
Very good	10%	10%	20%	20%	40%	15%
good	60%	65%	70%	65%	50%	70%
General	25%	25%	10%	15%	10%	15%
poor	5%	0	0	0	0	0

Table 4
Survey for the course of "Architectural design"

Item / Grade	Learn from teamwork	learn from competition	Learn from evaluation
Very good	15%	10%	20%
good	45%	55%	50%
General	25%	25%	25%
poor	15%	10%	5%

Improvement of Students' Ability

It can be seen that the students improved their self-learning capacity and team spirit significantly after this architectural design. Although the products designed by the students can not be perfect with their current limited knowledge and skill, but they had exhibited their creativity, interests and care for the society and environment, which are expected to be retained and developed for their lifetime. There is a case indicated the promising progress of the student's CDIO competencies. A team consists of three girls that chose the project "Adaptive" residence.

Self learning capacity

This task was relatively difficult for a beginner. When the course started, a girl worried that she could not do it with her limited knowledge and ability. Teachers encouraged her to process her work step by step as long as the progress can be seen. So she went to the process frankly, she did field research, analysis design case with teachers, then took part in team discussions, followed by carefully drawing, writing the text, presentation and improving program . After the work, she had accumulated a lot of first-hand information gained through discussion, and the draft. At end of the day, the girl told teacher that now she can face to the design work without being afraid of. This course enhances not only the potential to self learning, but also the confidence of students.

Teamwork ability

The complexity of architectural design requires students to adopt teamwork to work together for a job. As shown in Figure 1, it is a standard floor plan for residential building. It is rely on teamwork to determine the consistently space sizes and various components size. One team member said in a report that "In this course, I learnt how to communicate and discuss in a group to reach a consensus, more than how to design. We have to divide the work,

cooperate in teamwork and be good at listening to the views of others. Only by team can we finally get to our results."

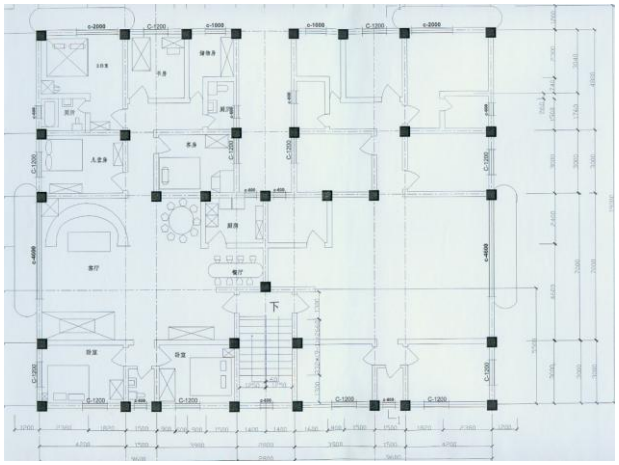

Figure1. The standard floor plan for residential building

The ability to develop products in social system

The team's task is to develop a "adaptation" residence solving the multi-generational co-live and the residential population change, which is a typical task of developing product to meet the needs of society. First of all, the team focused on the contents of the current family life, the one-child family composition and population changes, as well as the elderly and their children separated in space and spatial variability; then used their knowledge to arrange the function, space and components of building; after they took part in the show and presentation in class, expressing their design ideas and features, accepting the teacher and student evaluation, they improved the design finally. This CDIO process is consistent to the actual development of products logically. Students naturally exercise the ability to develop products in social system.

As shown in Figure 2 is the improvement of team at CDIO process compared before and after. On the show in class, other students acted as "critical customers" and pointed out that the lighting problems, the room's condition is not comfortable, the windows do not quite reasonable, and the doors are not reasonable with the structure in pre-program. The team accepted these advices and improved their program. One team member said in report that" The biggest gain is that we are able to constantly optimize our desired "adaptive" residential building. In fact, I think we will have a lot of improvements, when we enrich the professional knowledge. We will really be able to design our dream home! "

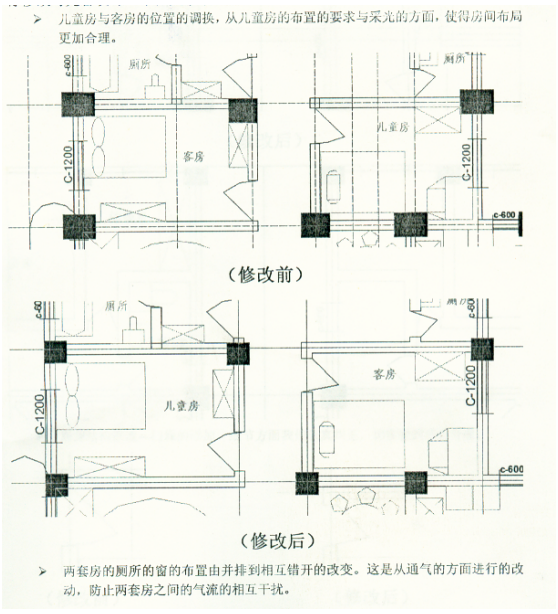

Figure2. The improvements for plan

Foundation of the Followed Course

This course is a secondary project of integrated curriculum system that based on EIP-CDIO mode. There are other projects such as "structural and geotechnical engineering design" and "advanced Civil Engineering design" followed [3].

The team studying methods and the form of exchange that formed in this course will be retained. At the same time, the outcome of this design will be the research subjects of the following curriculum. Students can sustain thinking and improving the residential building and construction "design" when they are in the process of deeper expertise. In particular, this project will cultivate the ability to help students get to their broader professional fields.

THE PROBLEMES AND CHALLENGES

Evaluation of Capacity

The curriculum developed capacity-building objectives (in table 1), and have achieved some success. However, the evaluation of capacity-building is mainly by subjective "feelings" of teachers currently. It is important to find more objective and effective assessment methods.

Motivate Student's Teamwork

In this course, teachers try to motivate student's teamwork. Although the use of the "competition" and "add creative points" has been generally welcomed by students, there are always free riders in team efforts. How to reduce the numbers of free riders and to educate on team spirit, integrity and team ethics is still a problem to be solved.

Use of Error-correcting-based Learning Methods

Driven by design motive, coupled with self-learning method, students need to access and collect a large number of knowledge, data and examples. These may come from textbook. More frequently they are collected from the internet. The information quality and credibility of the data can be very different. The students are still lacks of necessary knowledge and skills to make the judgments. So mistakes are inevitable. Some of our students encountered these problems and hesitate to go any further. They felt much more comfortable relying on the teachers. Teachers should have awareness of the use of error-correcting-based learning methods to help the students find relevant and correct data. In the new model, teachers also should face up to students to achieve the level of the design problem has always been to improve for the purpose of student ability rather than knowledge of the rights and wrongs of the past to high demands.

Faculty Competency

EIP-CDIO requires faculty much more than simple knowledge transmission. Like what is common in the world, most engineering faculty may not have strong engineering experience. How to improve the faculty engineering and CDIO competency would be a serious challenge. Faculty members should update their pedagogical concepts and conduct. Transform from traditional teacher's role to facilitator's role.

CONCLUDION

Shantou University College of Engineering, Department of Civil Engineering is exploring the CDIO engineering education philosophy into practice by CDIO approach, within the Chinese environment. A Design-Directed "Architectural Design" course was transformed and implemented. The practice has achieved our anticipated goal. Favourite results have been achieved. We will continue to our reform to solve more problems.

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Biographical Information

Yingzi Wang is a lecturer of the Department of Civil Engineering, Shantou University. Her current scholarly interests include Urban planning and Architecture. E-mail: yzwang@stu.edu.cn

Yunping Yang is an experimentalist of the Department of Civil Engineering at Shantou University, her current technological interests include Structural Design, Engineering Economy and Project Cost Estimation. Before joining Shantou University, she had worked as a structural engineer for almost 20 years. E-mail: ypyang@stu.edu.cn

Xiaohua Lu is an Associate Professor and Deputy Director of the Department of Teaching Affairs of Shantou University. His current scholarly interests include Steel Structures, Concrete Materials and educational reform. He is one of the key leaders in developing and implementing EIP-CDIO curricula at Shantou University. E-mail: xhlu@stu.edu.cn

Guangjing Xiong is a Professor and Head of the Department of Civil Engineering, Shantou University. His current scholarly interests include structural evaluation and rehabilitation, concrete materials and civil engineering curricular reform. E-mail: gjxiong@stu.edu.cn

Corresponding author

Prof. Guangjing XIONG
Dept. of Civil Eng. Shantou University
SHANTOU, GUANGDONG, P. R. CHINA
515063
Tel. 0086-754-2903242
Fax 0086-754-2902003,
E-mail gjxiong@stu.edu.cn