CDIO in Practice in Cornerstone Project for Civil Engineering Program

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Abstract
The College of Engineering, Shantou University has adopted the CDIO Initiative. One of the aims of the reform is at cultivating creative engineering graduates with CDIO competencies. Students of the 2006 intake is the first cohort adopting the CDIO curricular. This paper introduces the implementation of the cornerstone project taken by the program of civil engineering. Discussions are given to curriculum objectives, contents, teaching methods and evaluation methods. Analyses are also given on the impact of the practice to the ability, knowledge and personality of the students. Based on the process and observations problems are discussed and future improvements are proposed.

Keywords:
CDIO; Cornerstone Project; Reform; Civil Engineering Program;

INTRODUCTION

College of Engineering, Shantou University has adopted the CDIO Initiative[1]. The new curricular of the civil engineering program requires 6 team based projects[2][3]. The first of them is the cornerstone project “Introduction to civil engineering design”. It is designed to let the students have an overall perspective. One of the aims of the reform is to cultivate creative engineering graduates with CDIO competencies. Students of the 2006 intake is the first cohort adopting the CDIO curricular. This paper introduces the implementation of the cornerstone project taken by the program of civil engineering. Discussions are given to curriculum objectives, contents, teaching methods and evaluation methods. Analyses are also given on the impact of the practice to the ability, knowledge and personality of the students. Based on the process and observations problems are discussed and future improvements are proposed.

"Introduction to Civil Engineering Design" is the successor of "Introduction to Civil Engineering ". The goal of the old course was to understand the curriculum, civil engineering and the relationship between civil engineering and mathematics or mechanics. It called a desire to learn, and develop self-learning habits. Its learning content included all Civil Engineering field. The main teaching and learning method were carried out by classroom teachings (16-24 hours), students’ self access to information. The assessment was made by grading a course report at the end of the semester.

"Introduction to Civil Engineering Design" is now transformed into a project-based course. It is the cornerstone project of the new curriculum. It puts students in a broad and active design environment where they learn and use technical and non-technical skills, exercise and design. This cornerstone project uses thirty-two contact hours. The curse was first put in practice for the 2006 cohort.

CURRICULUM SYNOPSIS

Objectives

The objectives of the course has been shifted from "understand civil engineering " to "build up a civil engineer's perspective" and to "cultivate EIP-CDIO competencies". Table 1 lists the levels of related competencies designed to build up using the "I,T,U" [4] activities. To reach these, the students are assigned to plan the reconstruction of a local island. To fulfill the task they will have to consider social and environmental problems, as well as building up a civil engineer's perspective. It is expected to stimulate the students' interest in the discipline and to cultivate their personal, interpersonal and CDIO competencies.

Table 1 Ability interrelated EIP-CDIO mode

		I	T	U
PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES	ENGINEERING EASONING AND PROBLEM SOLVING	C	B	D
	EXPERIMENTATION AND KNOWLEDGE DISCOVERY	C	C	C
	SYSTEM THINKING	C	C	C
	PERSONAL SKILLS AND ATTITUDES	A	B	B
	PROFESSIONAL SKILLS AND ATTITUDES	C	C	C
INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION	TEAMWORK	A	B	A
	COMMUNICATIONS	A	A	A
	COMMUNICATIONS IN FOREIGN LANGUAGES	C	D	D
CONCEIVING, DESIGNING, IMPLEMENTING AND OPERATING SYSTEMS IN THE ENTERPRISE AND SOCIETAL CONTEXT	EXTERNAL AND SOCIETAL CONTEXT	C	C	C
	ENTERPRISE AND BUSINESS CONTEXT	C	C	C
	CONCEIVING AND ENGINEERING SYSTEMS	C	B	B
	DESIGNING	C	B	B
	IMPLEMENTING	C	B	B
	OPERATING	C	B	B

Content and Method

The implementation of the project is composed of three parts. The first is part contains basic civil engineering principles and knowledge, introduction to disciplinary subjects and design guidelines. This was accomplished mainly through the classroom lecturing. It was finished in six hours, a total duration of three weeks.

The second part was an extension of what the students had learnt and perceived. They needed to do self studies and shared through classroom discussions. This helped them to perceived the profession and conceive the assigned project. Another six hours, three weeks were allocated for this part.

The third part was the team design project. Each team needed to plan the reconstruction of Wuqiao Island as sketched in Figure 1. The title of the project was “my dream home”. The students were divided in groups of three. With little knowledge on civil engineering, the students needed to make civil plans for the new town. They would have to plan the residential, commercial, political, social, educational, and recreational districts and plan the traffic facilities, like roads and bridges. In this project, each group also needed to pick up one item in the plan, such as a building or a bridge, to given more specifications on description/design. The students needed to indicate the functions, format, styles, dimensions and materials to be used for the selected design.

Throughout the design process, the students did independent inquiry learning and worked in collaboration with their teammates. They collaborated and competed among teams. In the course of the project, the teachers guided students to through an entire Conceive - Design - Implement - Operate cycle. The project was carried in two stages. In the first stage was the design stage and the second was an evaluation stage. In the first stage, each team did urban planning, transport planning and construction of a building or a bridge. In the second stage, the whole class evaluated their designs three times (6 hours). During the evaluation, each team displayed its urban planning, transport planning and construction design. The whole class would then evaluate the design and gave their comments on the design. The team displaying the design needed to defense or debate or accept the comments. After the evaluation, each team needed to revise its design according to the comments of the class. This evaluation of the designs stimulated the students’ interest. It also form a mini operation process.

Assisement

At the end of the project, each team needed to produce four reports: an investigation reports cum project plan; a landscape plan with explanations; a detailed plan of a residential district with explanations; the design of a chosen building or bridge with explanations. On top of these, each student needed to submit a personal reflection on what he or she had contributed to the team and what he or she had leant.

It is unrealistic to expect the students to produce designs satisfying contemporary professional standards. However, the process gave the students opportunities to perceive a relative complex system, conceive the project and a brief experience of the profession. An emphasis was put on experience CDIO process. For Urban Planning and Design distinctive features with reasonable explanations are the only requirements in assessment. It was to encourage them to develop their innovative awareness and desire. The overall grading of a student was based on his or her design work and general performance. Specifically, a grade was made: design work 30%, personal reflection 50% and classroom communications 20%. Heavy weight was given to personal reflection to emphasize on team spirit and to discourage “free riders”.

IMPACT TO STUDENTS

Based on a student questionnaire survey and faculty observations of the project process and results, we summarize the impacts of the project on the students in three aspects, namely, the students’ abilities, the students’ learning efficiencies and the promotion of EIP behavior. Table 2 summarizes the student feedback at the end of the project.

Table 2 A brief summary on a questionnaire survey at the end of the project

	Improved my self-learning skill	Improved my practical skill	Improved my communication skill	Improved my creativity	I understand civil engineering better	Satisfy what I have learnt	I feel the reform is successful
Strongly agree	20%	15%	20%	10%	15%	10%	15%
agree	65%	65%	70%	85%	50%	70%	60%
Fairly agree	15%	20%	10%	5%	35%	20%	25%
Not agree	0	0	0	0	0	0	0

Students abilities

Figure 1 shows the student production of the master planning of WUQIAO island of a team. The team went to the actual site to do a field investigation. They found that there were many underwear stores on the island. Taking social and cultural considerations they suggested "making full use of all existing resources to transform the island into an international underwear fair center”. The design theme of the design was determined as "high tech life, Green and Clean ". So, starting from the international underwear fair center they planned the five major functional areas: hi-tech industry, intelligent life, education, commercial trade zone, and recreation and tourism resort. They have displayed strong abilities to work independently and to learn independently. The space layout, road traffic, architectural and landscape system were worked out by team collaboration. Strong team spirit and communication skills have been developed in the course of the project.

It also can be noticed that the students consider issues from creating a harmonious social relations, good ecological environment and high-tech high-quality business environment, to comfortable living conditions, unique scenes, and other aspects. This demonstrates their project - system adaptation and control capability. The five major functional areas are reasonably laid out even in professional eyes.

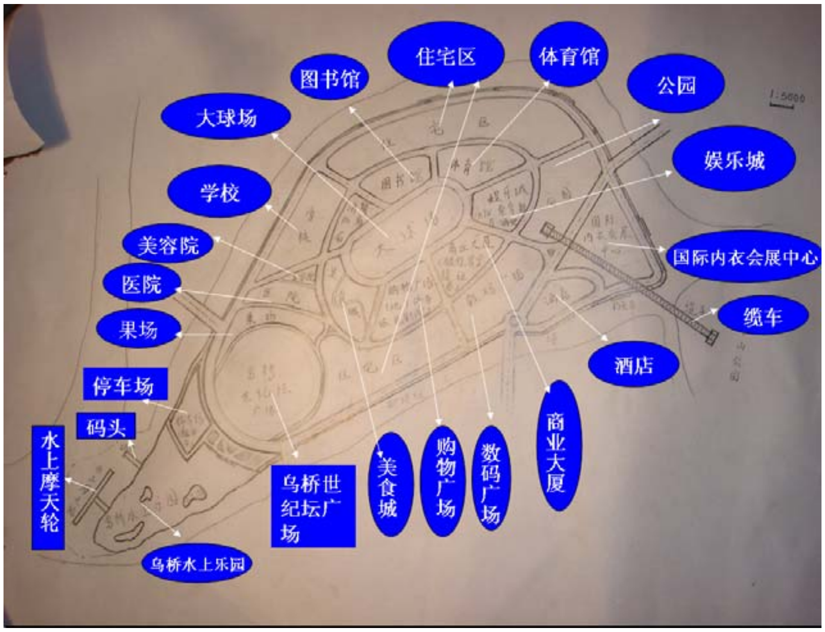

Figure 1 : the master planning of WUQIAO island

Students learning efficiency

Studies showed that, only 25% students in classes can learn by hearing; about 50% recalls well visually the things that are seen or read; and most harvest more when they use them in real-life activities[5]. Comparing to the old fashioned sitting and listening, the students learn much more through such project work exchange of harvesting, and thereby more treasure, more firmly grasp knowledge. By using this project, the students learn much more and master deeper knowledge than the pre-reform lecture-only classes. Gradually they expand their knowledge base and build up their CDIO competencies.

This project is also the bases of the students' future projects [3]. Individual designs of the master plan will be picked out to make in depth, detailed designs. At that time the students will find out whether their designs are reasonable in professional sense. They will have to make corrections and modifications. In this sense, will continue to improve their work products and develop professional skill as well as the CDIO competencies.

Promotion to EIP behavior

The implementation of the CDIO initiative gives an emphasis on ethics, integrity and professionalism, calling it the EIP-CDIO reform. The special emphasis was imposed because these are the components have been traditionally neglected or are lack in our current professional conduct. Therefore, we want to use all opportunities to cultivate these features. Team design environment enables the students to directly experience the need and the importance of EIP.

A student wrote in a personal reflection "through this project I further realize the virtue of EIP-CDIO approach. In the approach we have to learn how to study, how to communicate and how to cooperate. After this project I have gotten a deeper appreciation of a civil engineer. I realize that we need not only to posses a rich, comprehensive professional knowledge, but, more importantly, it is necessary to be professional in learning and conduct".

THE PROBLEMES AND CHALLENGES

Studying resources

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. It is important to develop some ways to help the students find relevant and correct data. Some of our students encountered this problems and hesitate to go any further. They felt much more comfortable relying on the teachers.

Teamwork supervision

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 tough problem to be solved.

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 taking the CDIO engineering education philosophy into practice within the Chinese environment. With the design-directed CDIO approach, "Introduction to Civil Engineering Design" was designed and implemented. The practice has achieved our anticipated goal. Favorite results have been achieved.

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