Evolution of Civil Engineering Curriculum in Polytechnic Universities in Taiwan: an innovating curriculum of construction engineering

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ABSTRACT
This paper describes the development of an innovative curriculum in the Department of Construction Engineering at Chaoyang University of Technology in Taiwan. The new curriculum is aiming to strengthen the integration of both theory and practice aspects for fundamental structural design and construction management courses. To accomplish this goal, a series of Construction Operation Lab (COL) courses is designed. After two-year test run of the new COL courses, a surveyed result for seeing the effect of this innovating lab program on the participating students is reported. In addition, the lessons learned from the test run are discussed as well.

INTRODUCTION
In the past decade, the higher education system in Taiwan has been extensively reformed into two education systems, the traditional high education system and the evolved polytechnic education system. The evolution of a polytechnic education system was started because of the government's decision in increasing the higher education opportunity for the vast amount of the graduates from the vocational high schools and junior colleges. As a result of this policy, not only the government itself but also many private organizations were encouraged to contribute to the foundation of many new universities and colleges in which more than two third of the newly founded or reformed institutes are classified in the so-called polytechnic education system. The curricula in the Civil-Engineering type departments of these polytechnic universities and colleges mainly followed those in the Civil Engineering departments of the traditional universities with some emphases on the summer internship and fundamental design courses.

As the high-technology knowledge and the electronic information become more dominant in today’s engineering education than ever, Civil Engineering departments all over the world have to not only create more technology-oriented courses in the curriculum but also adjust contents of their basic curricula, which may have been followed for decades. In order to adapt itself to this technology-orientated trend, the department of Construction Engineering at Chaoyang University of Technology (CYUT) continuously adopted several technology-based courses as worldwide universities did. Meanwhile, the department also proposed a new curricular idea to allow students to integrate fundamental design and management knowledge with a realistic construction project on campus. As a result, an innovative practice program, Construction Operation Lab (COL), is currently developing to fulfill this particular ethos of the department. In the following sections, the background of the polytechnic education in Taiwan is introduced. The strategy of shaping the curriculum of the Construction Engineering department at CYUT in Taiwan during the past eight years is briefly described. The result of a comprehensive survey of the improved curriculum which was initiated three-year ago are summarized with highlights on the evaluation of students’ learning motivation and their preparedness to the construction project. Based on students’ performance in the...
COL courses during the first two years of a four-year test run, lessons learned from such program and recommendations to other departments that might be interesting in initiating a similar program are made.

BACKGROUND OF THE POLYTECHNIC EDUCATION IN TAIWAN
Taiwan’s economics was mainly on agriculture about half century ago, then was gradually shifted from agriculture to light industry. In the 1950’s and 1960’s, Taiwan’s industrial structure was of labor-intensive agro-industry. As such, Technological and Vocational Education (TVE) was devoted primarily to train labors with low-level skills. The junior professional schools were dominant in the TVE system at that time. However, the junior professional schools were terminated because of a major change in Taiwan educational system in 1967. The change of educational system is to extend the compulsory education from six to nine years. Therefore, the two-year and five-year junior colleges and senior professional high schools became the major institutions for educating workforces.

Taiwan’s economy was changed from being labor-intensive to technology- and capital-intensive in the 1970s into 1980s. This transformation had a great impact on the Taiwan’s TVE. Due to the market’s demand of high-level skilled worker, it is necessary to upgrade the educational programs of TVE and to nurture more higher-level technicians and engineers. Under this circumstance, the first polytechnic institute, which is renamed as National Taiwan University of Science and Technology (NTUST) currently, offering two-year and four-year bachelor degrees was established in 1974. Construction Engineering was one of few departments established in the beginning stage. The name, Construction Engineering, indicated that the different character of its graduates was different from the Civil Engineering departments in other traditional universities. However, in terms of the curriculum design, there is almost no significant difference between the first Construction Engineering department established at NTUST and traditional Civil Engineering departments. In the 1990s, the computer and semi-conductor manufacturing become the major industries and the backbone in Taiwan’s economics. Followed by this change and under the policy by the Ministry of Education, most junior colleges started to upgrade themselves to polytechnic institutes, or further advanced to technical universities.

Statistics show that the number of students enrolled in the TVE programs pursuing their doctoral, master’s, and bachelor’s degrees, or junior college diplomas were 143, 752, 4,438, and 304,271, respectively, in the year of 1990; and 820, 8,260, 245,262, and 421,123, respectively, in the year of 2001. Based on these data, the quantity and quality of the TVE graduates of different programs show a significant increase in the last 10 years [1]. According to the data from the Ministry of Education, there are a total of 12 universities of technology, 55 institutes of technology, 19 junior colleges, and 178 senior professional high schools in the year of 2001. Table 1 shows the distribution and growth of TVE schools.

EVOLVED ETHOS AND EDUCATION PHILOSOPHY AT CYUT
The curricula for civil or construction engineering at most polytechnic universities in Taiwan are mainly based on those adopted by the leading universities in the USA. The original design of such curricula was to expose students to a broad knowledge in
engineering and applied science rather than to guide students to a suitable direction according to their abilities and the future competition. A decade ago, there was almost no difference between the contents of the curriculum for a traditional civil engineering department and those for departments of polytechnic universities/colleges. However, due to competition between universities, the curricula of the department of civil or construction engineering in each university have to be designed to fit the needs of the local and/or global industries and the ability of each student. As a result, an innovating strategy different from the traditional civil engineering program is evolving at the Department of Construction Engineering in CYUT.

Over the years, the faculty members in the Department of Construction Engineering have debated on some key problems regarding the department’s curricular planning. These issues include what kind of ethos the department should establish and how to fulfill it, what the appropriate amount of credit hours for the required courses should be, and what these courses would be, etc. With its initial reputation being pretty well and being recognized as one of the key departments of this newly incorporated polytechnic university, the Department has focused its development in technology related aspects with emphases on the areas including structural engineering, geotechnical engineering, and construction management. Based on the traditional curricula, the Department tried hard to construct a unique characteristic of its own and maintain its competitive strength as one of the leaders among similar bachelor-degree programs in Taiwan.

**Initial curriculum structure**
The Department of Construction Engineering at CYUT selected the “specialty” strategy to set up its degree program when it was established eight years ago. To accomplish this goal, the Department initiated two unique curricula different from the other civil engineering departments. The first one is to set up a required practice program consisting of a one-semester preparing course, a two-month summer job, and a one-semester presentation course. In the preparing course the students are instructed with interview skills, contract related issues, and important laws. Students are expected to follow a certain timetable and finally obtain a summer job at the end of the semester. In addition, basic design principles and estimating and planning rules are also briefly reviewed in the first semester. During the working period in summer, students have to gather information for their reports and presentations, which are scheduled in the second semester. For the entire second semester, students are taught the presentation skills. They also learn how to write a report and share their experiences with peers.

Along with the first key curriculum, the second one has to be established through adding more design and management courses as requirements in order to ensure students’ ability when working in a consulting firm or at a construction site. In the initial curricular plan, the courses of Advanced RC Design, Steel Design, Foundation Engineering, Project Planning and Control, and Contacts and Specifications were added in the requirement list for the three major areas, respectively.

**Assessment of initial curriculum**
According to the graduates of classes 1998 and 1999, the enhanced design courses in the junior and senior years might not be as effective as what the department had originally planned for their job-hunting and exams of professional engineers.
It is of particular interest to note that, according to the observation to the department’s graduates in the past four years, the unexpected consequence of this approach is that the students seem lacking of basic knowledge of being an engineering bachelor. The fact is that their design ability and practical experience are not necessarily better than those from normal civil engineering departments where students are not supposed to be trained by the aforementioned two key curricula. Part of the reason might be due to the fact that the initial curriculum lacks the integration between the practical considerations in realistic projects and all related design courses. Moreover, he original practice program may not provide as good internship experiences as they were planned. In some cases the summer internship even became merely an opportunity of part-time job as interpreted by students.

**KEY DEVELOPING PROGRAM AT CYUT**

In order to make up the deficiency in curriculum integration and improve the quality of internship, an innovative program, namely a series of Construction Operation Lab (COL) courses, is designed. The goal is to integrate the core courses among structural engineering, geotechnical engineering, and construction management such that the students would be more competitive once they enter the job market.

**Construction operation lab courses**

The development of such unique lab courses is based on the characteristics of the students, expectation of the industries, and the competition in the future. The revised practice program combines a reformed curriculum structure and a versatile internship choice. Among the four internship categories, the innovating construction operation laboratory is obviously the key character. These operation programs can be separated into three courses as COL-I, COL-II, and COL-III. These three courses are implemented into the required practice program during the second semester of junior academic year, summer term between junior and senior academic years, and the first semester of senior academic year respectively, aiming to enhance the hands-on training of students for future career.

In course COL-I, the contents are designed to be construction management oriented. Students learn how to make a plan for constructing a simple building structure. In addition, the related skills (e.g. drawing schedule bar chart and creating project budget) of achieving such plan are emphasized. A relatively simple but comprehensive project (so far is to construct a one-story RC building) is designated to students in the COL-II course. This project has been designed by students in a previous class during their COL-III course and should be taken up by students later during the summer term. Thus, students can gain the practical experience and prove their work abilities through such a construction project.

After students obtain practical experience from a specific design project, course COL-III is intended to emphasize on both design and construction aspects, how to complete a design project similar to the one that they have constructed during the summer. As a result, during course COL-III, the key course materials to be taught are the integrated design knowledge and technologies related to both structural engineering and foundation engineering.

**Innovative on-campus technology learning camp - course COL-II**
Course COL-II is the core of the aforementioned series of COL courses. The goal of COL-II is to improve the quality of internship. In order to access the goal, the department believes that setting up an on-campus camp for providing students the on-hand practical training might be a good approach. In this course, students are grouped to several construction teams such as masonry workers, steel assembling workers, and form assembling workers. Then, students should build the project that has been planned in course COL-I. All the materials and equipments used for carrying out the project are provided by the Department. On the other hand, in addition to full-time instructors who taught course COL-I, a couple of experienced engineers hired as part-time instructors are arranged by the program committee to direct the students during the entire construction period (normally a whole summer). Through completing a real construction project all by students, this course provides them with a chance to obtain practical experience. Furthermore, learning experience of good quality are provided in a safety construction environment and enriched by unceasing instruction during whole construction period. With this kind of training program, students not only observe and involve in the process of constructing a project but also learn how to do the documentation work. It is believed that this innovated on-campus technology camp will provide the students with a great opportunity to strengthen their competitiveness in their initial careers.

SURVEY OF ON-GOING CURRICULUM REFORM
Previously, the students had been required to take Special Topics and Practice in their junior and senior years. The requirement is modified for students enrolled after 1998. To evaluate the potential influence of the latest curriculum reform on all students and to understand the effect of this innovating lab program on the participating students, two types of survey were conducted.

The questionnaire was designed to compare the response of students who participated the new course with those who did not participate. Both graduates and students in the senior class were sampled. The number of returned questionnaires is 28 for graduates (Group I) and 74 for senior-class students (Group II). At a 0.05 significant level, these two groups differ in 32% of the questions according to the student t-test. Based on scales 1 to 5, the average score of Group II is higher than that of Group I in questions 3, 5, 7, 11, 14, 18, 21, and 24, as shown in Table 2. In general, students felt more confident in performing tasks such as structural design and quality inspections. Group II responded more positively about the on-going curriculum reform. In short, we found the implementation of Operational Construction Lab was widely supported by both our graduates and senior-class students. However, the results of survey also indicated a need to enhance the practical side in the curriculum.

SUMMARY

Program status
As far as the on-campus technology camp is concerned, the setup of a construction lab is under way and can be expected to be fully functional after a three-year (2001-2003) test run. The capacity of this camp is estimated to be about 30 to 40 students once it is settled down.
Currently, the test run of the series of operation courses is implemented from year 2001 to 2003. The students in the classes 2002 and 2003 have involved in the test run of an entire series of operation courses. A one-story-high reinforced concrete structural building was designated as the real project with the exercise of design, plan, and construction in the courses for students in both classes. Figures 1 to 3 show the appearance of the building at three different stages during the construction period in the summer of 2002.

The original plan of the courses is to teach students how to design and construct a building throughout the first, summer, and second semesters. However, after running the course in the class 2002, the department noticed that without practical construction experience, the students had a hard time to comprehend how to design a building in details. Therefore, main course contents of the first and second semesters are exchanged. The revised schedule is currently being carried out by students in the class 2003.

In addition to the adjustment to original course schedule, an important decision made by the Department during the first-year test run is of particular interests. The University (CYUT) was willing to grant the department several possible construction sites to conduct the on-hand training through building various types of structures of ordinary size. The Department soon found out that managing such a building program in fields would not be as efficient as an in-door space for the reasons of material storage, performing demonstrative instructions, avoiding severe weathers, and so on.

As a result, the Department strives for its important goal to set up a laboratory for the implementation of constructing realistic projects. Fortunately, as the laboratory plan was proposed, it was fully supported by the University and was partially sponsored by the Education Administration of Government as a four-year education-improvement project. The architecture design of the laboratory is currently under way. Moreover, a temporary light-gage steel warehouse was built at the selected site for the laboratory to allow the students of class 2002 to be able to carry out their COL-II project prior to the completion of the laboratory. The test run at this temporary warehouse is expected to provide useful information in revising the design layout of the laboratory.

Learned lessons and recommendations
Some questions are raised after the test run in the first two years. The reinforced concrete building constructed in summer of 2002 by students costs about US$30,000. The Department notices that raising such amount of funding every year is not easy. In addition, the building should be demolished in order to evacuate the space for later students to construct a similar building in the following year. Moreover, the demolishing process causes pollution that could threaten local environment. The critical lesson learned from the test run of this program is that the RC structure might not be the appropriate selection for the implemented course project (at least it should not be designated every year). Consequently, this course will be adjusted to focus more on steel structure buildings than on RC buildings.

From the test run experience of the innovative COL program, a couple of recommendations can be concluded as follows:

1. For those students who have participated in the COL courses, their performance in career should be monitored after they graduate. A general survey should be
conducted so that the effect of practical training gained from COL courses on students’ performance in their jobs can be evaluated. Continuous improvements in the curriculum reform can thus be done according to the survey results.

2. Since demolishing RC structural results in pollution problems, the COL courses should be adjusted to focus more on teaching projects associated with the design and building of steel structures. It can be expected that steel structural projects would lead to less construction wastes during the demolition process.

3. Presently, the foundation contents associated with the basic design/management courses that are required in carrying out a COL project are briefly reviewed and integrated in the COL courses. Students have no idea what a COL project may look like when they first take the basic design/management courses. To shape a more efficient curriculum and to fit in the COL courses, the introduction of COL projects should be included or even considered as the case studies in classes when students take the RC-Structure Design, Structure Analysis, Steel-Structure Design, and other related design courses.

ACKNOWLEDGEMENTS
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REFERENCES


Table 1 - Distribution and growth of TVE schools

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<th>Institution</th>
<th>1995</th>
<th>1997</th>
<th>2001</th>
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<tr>
<td>University of Technology</td>
<td>0</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Institute of Technology</td>
<td>7</td>
<td>15</td>
<td>55</td>
</tr>
<tr>
<td>Junior College</td>
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<td>61</td>
<td>19</td>
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<td>Professional High School</td>
<td>203</td>
<td>204</td>
<td>178</td>
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Table 2 - Selected questions from the survey

<table>
<thead>
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<th>No.</th>
<th>Questions</th>
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<tbody>
<tr>
<td>3</td>
<td>I have great expectation for the curriculum reform.</td>
</tr>
<tr>
<td>5</td>
<td>I understand the course content of Special Topics and Practice has been</td>
</tr>
<tr>
<td></td>
<td>altered significantly.</td>
</tr>
<tr>
<td>7</td>
<td>What I have learnt helps me to understand the design process.</td>
</tr>
<tr>
<td>11</td>
<td>What I have learnt helps me to engage in structural design and calculations.</td>
</tr>
<tr>
<td>14</td>
<td>What I have learnt helps me to work on engineering drawings and</td>
</tr>
<tr>
<td></td>
<td>documentations.</td>
</tr>
<tr>
<td>18</td>
<td>What I have learnt helps me to complete layout.</td>
</tr>
<tr>
<td>21</td>
<td>What I have learnt helps me to calculate the load-carrying capacity of</td>
</tr>
<tr>
<td></td>
<td>shoring.</td>
</tr>
<tr>
<td>24</td>
<td>What I have learnt helps me to perform quality inspection of rebars and</td>
</tr>
<tr>
<td></td>
<td>concrete.</td>
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</table>
Fig. 1 - Completion of beams of the RC building at ground level.

(a) steel assembling       (b) concrete casting

Fig. 2 - Construction of top-floor slab of the RC building.

Fig. 3 - Façade tiling for the RC building.