Total Design Experience in Civil Engineering Education

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Abstract

This paper identifies the need to incorporate design concepts into Civil Engineering Curriculum from the freshman through the senior years. The existence of a single requirement for a capstone senior-level design course, which is implemented in most engineering programs as per ABET basic requirements, does not fulfill the goal of preparing design-oriented, creative engineers. This paper describes an integrated approach to the inclusion of design aspects in those courses most geared towards design. It also demonstrates that design is a total educational and learning experience, and its success depends on the implementation of a program which integrates a number of desirable educational approaches. Special emphasis is given to the corner-stone and capstone design courses.

I. Introduction

This paper presents an integrated program which will incorporate design concepts into the civil engineering course curriculum from the freshman through the senior years. This program not only includes design in civil engineering course contents, but also outlines teaching mechanisms and educational activities which enhance design value for both faculty and students.

Since the Fall of 1994, the Civil Engineering program at Kuwait University has included a senior-level capstone design course in its curriculum structure. While the inclusion of this single course is an essential ingredient of a program which trains competent design-oriented engineers, it nonetheless falls short of achieving this goal due to a variety of factors.

Studies have shown that engineering design is a crucial concept in the total educational and learning experience [1], and its success depends on the implementation of a program which integrates a number of desirable educational approaches. These approaches include, but are not limited to: creative thinking, active learning, increased awareness and participation, integrated research, teamwork, decision making, communicating, managing conflicts and interacting with the public and the professional community. [2] describes these educational approaches in detail.

In addition to the senior capstone design course, the College of Engineering at Kuwait University have launched two new efforts. First, the introduction of a corner-stone design course at the sophomore level starting Fall 1999. Such early introduction to design concepts and applications will aid in providing better understanding and appreciation to the challenges facing engineering disciplines; thus, stimulating students creativity and interest in engineering. Second, the integration of design into the civil engineering curriculum through examples, case studies, open-ended problems and real-life projects.

II. Integration of Design into the Course Curriculum

Integrating design into course content is the main aspect of the total design educational concept and a key ABET requirement for engineering programs [3]. The heart of engineering education is to develop the ability to design, i.e. to engineer is to design. This includes the design of components, systems, products, and/or projects. Design cannot be taught as a separate entity, but rather as an additional tool which can be used to teach the fundamentals of engineering [4]. The challenge here is to introduce design into as many courses as possible, especially those courses geared towards design principles, while keeping the focus on the subject material of each course. This is an incremental continuous development of design concepts for engineering students during their four or five years of undergraduate education. The process starts with freshmen by teaching them basic design concepts and exposing them to small-scale design problems. Then, sophomore students can be given open-ended problems and encouraged to participate in problem formulation. For a given open-ended problem, no single solution can be unique and therefore grappling with such problems is the best way for the student to learn to apply the various analytical and computational tools that are available. During these first two years, students should be trained in the basic concepts of creative thinking, strategies for change, cooperative learning, productive teamwork and effective communication. These skills are essential for the real design process.

Then, junior students should be ready for a component or system design, e.g., thermal and moisture insulation of a structure. Case studies, mini-design projects and design laboratory experiments are suited to sophomore and junior students. Finally, senior students can wrap up their educational experience in a comprehensive capstone design project guided by both academic and industrial experts.

The process for integrating design into the course curriculum can be broken down into the following steps:

1. Examine and identify those courses within the existing Civil Engineering Program whose effectiveness will be further enhanced by integrating design experience into their contents. Special attention should be given to CE200 Civil Engineering Drawings, CE202 Statics, and CE204 Strength of Materials courses because: 1)

these courses are design-oriented by nature and 2) students will probably continue in engineering if they find these courses interesting and practical.

2. Determine the percentage of design content for each course. Design content in civil engineering courses should range from 0.5 to 3 credits: from as low as 20% (about 0.5 credit) in courses such as *Engineering Materials*, to as high as 100% (3 credits) in the *Capstone Design* courses. [2] provides design content for each course within the civil engineering curriculum.

   Special attention should be given to the evaluation and selection of new textbooks for these courses since many authors now include design problems as part of their texts.

3. Prepare a library containing examples of methods, open-ended problems, case studies and mini-projects for each course. These examples should introduce ABET category content such as ethics, safety, economics and creativity. Ethical case studies are enlightening to students on matters related to plagiarism, sexual harassment, conflict of interests, etc. Such an exemplary library will help in the overall evaluation process and will serve as a reference for new instructors to develop their own design components.

4. Develop a methodology for the assessment and evaluation of the design-integrated program's effectiveness by both students and faculty. This assessment process includes documenting results and giving evidence that the results are applied for further development and improvement of the program.

III. Illustrative Example

At this moment, at the Department of Civil Engineering few faculties have introduced some design ingredients in their classes. Though, most of these classes are at sophomore and junior levels, but participation of student in terms of innovative ideas, data collection, implementation, and successful completion was extremely praise worthy. What follows an example of design oriented task was introduced in CE200 Civil Engineering Drawing:

Background

Kuwait has two major industries: Oil and Construction. Oil industry is located in a few restricted places, while the construction industry is wide spread. Because of the social and economic structure of the country, almost each family is some how related to the construction

industry. Most of the students before come to the college, they gather some ideas on such industry. Almost in every neighborhood the construction activities are present. This becomes the background of learning design process in CE200 Project — Civil Engineering Drawing for a Villa of 400 m2. The students worked in groups. Each group contained maximum three students.

Scope

a) Draw plans, elevations, cross-sections, materials schedule, etc.
b) Draw required structural plans, sections, and details.

Data Collection Process

Students are asked to visit existing construction site of such plot area, and gather data to:

a) Find Free space required to be left around the building by the local Municipal Authority.
b) Find the reasons, why such spaces have to be left for.
c) Find, dimension of each room, and justify them.
d) Find size of doors, windows, stairs, beams, columns, slab, etc.

Design Development Process

a) Use the above data to come up with the requirements of the class.
b) Prepare preliminary architectural plans.
c) Show preliminary structural system.

This is fully helped by the course instructors. But the students develop some sense of putting them, due to site visits.

Develop Final Architectural and Structural Drawings

a) Based on the ideas gathered from the site and class discussion, they were ready to produce drawings, where their design sense worked to some extent.
b) Some thumb rules were described regarding material selection, size selection, and reinforcement requirements.

IV. Conclusions

This paper has presented a number of educational recommendations for the realistic implementation of a total design experience into the Civil Engineering Curriculum. Special attention should be given to integrating design principles into engineering science courses. Fulfillment of these goals promotes graduates who, in the short term, are better able to meet the needs of the construction industry and, in the long term, are better prepared to solve problems in the rapidly changing professional world of engineering.

A civil engineering drawing project was presented to demonstrate how design experience can be integrated and introduced early in the engineering curriculum. Groups are now taking Capstone Design course with the same professor. It has been observed that they extremely equipped now for such senior class. In this last semester course, they are using all their design experience from freshmen to senior level classes.

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