# Industry Participation in a Capstone Design Course

**Sanjeev Kumar**

*Department of Civil Engineering Southern Illinois University - Carbondale, Illinois, USA, http://civil.engr.siu.edu/kumar/*
*Tel: (618) 453-7843, Fax: (618) 453-3044, kumars@ce.siu.edu*

**Abstract:** The guiding principle of Engineering Criteria 2000 is to assure that graduates of an accredited program are prepared to enter and continue the Practice of Engineering. ABET Criterion 3 outlines the outcome and assessment requirements that an engineering program is expected to demonstrate in their graduates. In summary, this criterion requires that the graduates of an engineering program should have professional and technical skills to successfully complete real-world projects. Most of the civil engineering programs all over the world require their senior students to complete a capstone design course. Several components of Criterion 3 can be incorporated in this design course. The department of Civil Engineering at Southern Illinois University - Carbondale also offers a capstone design course "Civil Engineering Design (CE 495)" as a part of the core curriculum. Keeping the requirements of EC 2000 in mind, the author has successfully introduced industry participation in the capstone design course by assigning practicing engineers to serve as technical advisor on the projects and inviting them for open discussions with the students. Based on the direct and indirect input received from the students and faculty, addition of industry participation in this course, has enhanced the students' understanding of the course contents. More input from the graduating students is being collected to further improve the course. Details of industry participation and criteria used for evaluation of students are presented.

**Keywords:** civil engineering design, curriculum, EC 2000, industry

## 1. Introduction

The ABET Engineering Criteria 2000 is based on what students learn in a course as opposed to what is presented in the course. ABET Criterion 3 - items *a* through *k* provides the outcome and assessment requirements that an engineering program is expected to demonstrate in their graduates. The requirements of this criterion can be summarized that the graduates of the engineering program should have professional and technical skills to enter and continue the Practice of Engineering. According to the program criteria for civil engineering and similarly named engineering programs prepared by American Society of Civil Engineering (ASCE), the civil engineering curriculum must demonstrate that the graduates have the ability to perform civil engineering design by means of design experiences integrated through the professional practice issues such as: procurement of work; bidding versus quality based selection (QBS) processes; how the design professionals and construction professionals interact to construct a project; the importance of professional licensure and continuing education; and/or other professional practice issues.

Most of the civil engineering programs all over the world require their senior students to complete a capstone design course. The purpose of the capstone design course is to provide opportunity to the students to apply the technical knowledge learned from other courses to real world projects. Most of the requirements of ABET 2000 criteria and ASCE program criteria could be incorporated in the capstone design course. Although, the contents identified by ABET and ASCE can be taught using textbooks, presentation of the material by practicing professionals can enhance understanding of the students. Wankat and Oreovicz [1] in a recent article published in Prism stated "the primary duty of teaching undergraduate engineers what they need to know to survive in the workplace falls to educators. But we need not go it alone in this task -- industry, which has vested interest in the quality and preparedness of engineering graduates, has a number of important roles to play in ensuring that their future employees are well educated." Therefore, input from potential employers of the students becomes an essential ingredient in producing successful engineers

The department of Civil Engineering offers a capstone design course "Civil Engineering Design (CE 495)" as a part of the core curriculum. Students enroll in this course in the final year of BS degree. This course provides the students the first opportunity to work as a member of the project team and solve a problem that is not listed *in the*

*back of the book*. The author has been the instructor for this course since Fall 1999. The objective of this paper is to present the author's experience in introducing industry participation in this course. Kumar [2] has provided discussion on integrating industry and technology into civil engineering curriculum.

## 2. Civil Engineering Design

The Capstone civil engineering design course at Southern Illinois University - Carbondale is a two-semester, six-credit hour course. The main objective of this course is to provide understanding of the basic concepts of planning, execution, and design of civil engineering projects to undergraduate students planning to pursue career in any area of Civil Engineering. The purpose of the course is to give students an opportunity to participate on a project design team, and learn how to apply tools and procedures learned in other courses to real-world projects and how the real-world projects progress from concept to completion. Discussion on contents of Part A and Part B of the course is presented below.

### *2.1 Civil Engineering Design - Part A*

The program criteria for civil engineering programs developed by ASCE recommends that the civil engineering curriculum must demonstrate that the graduates have the ability to perform civil engineering design by means of design experiences integrated through the professional practice issues such as: procurement of work; bidding versus quality based selection (QBS) processes; how the design professionals and construction professionals interact to construct a project; the importance of professional licensure and continuing education; and/or other professional practice issues. To satisfy this criterion, contents of the first part of the course (CE 495A) includes discussion on project development skills, team players and role of each team player, various types of construction contracts and delivery methods, various phases of a project, design and construction professionals hierarchy, type of construction projects, feasibility and cost estimation, project management, types of Contracts for design engineers, key factors in proposal development, formatting a proposal, engineering ethics and professionalism, risk analysis, building Client relationship, and how to successfully complete design by working as a member of the team of project design professionals. The class is divided into groups of 3 to 4 students and projects are assigned to each group. Each team selects project manager. Although final proposal is not the sole responsibility of the project manager, project manager is responsible for compiling the final proposal. The deliverables at the end of this part of the course include preliminary plans of layout of the project and a complete proposal to complete the design of that project. Each group is required to formally present and defend their proposal.

### *2.1 Civil Engineering Design - Part B*

The second part of this course (CE 495B) includes actual design of the projects, preparation of engineering drawings, and presentation of the final projects. Students are required to exercise few basic elements of consulting as discussed in a subsequent section of this paper. The team configurations are kept the same as during the first part of the course. Deliverables of each group at the end of this part of the course consist of a set of design plans, a complete set of calculations, and a project report.

## 3. Preparing students for professional practice

In order to better prepare students for professional practice, students are required to practice some of the basic elements of consulting which include keeping track of their time, taking good notes during meeting and telephone conversations, and communicating effectively to express their views in an organized fashion. As a minimum, the students are required to exercise the following:

### *3.1 Time sheets*

In a typical practicing engineering firm, a project is handled by a team consisting of Principal, Project Manager, Project Engineer, Drafts Person, Technician, and Word Processors/Clerical Staff. The role of each team member on the project is clearly defined and the cost of each team member's time to the project is different because of different billing rate. Therefore, each student in project team is required to keep track of his/her time spent on the project as a project manager, senior engineer, engineer, drafts person/technician, and word processor/clerical. Final manpower expenditure is calculated based on the billable rate of each category of work and time spent by each team member

on each of the categories. At the end of the course, students get the opportunity to compare the time estimated during the first part of the course and the time actually spent of the project during the second part of the project.

*3.2 Minutes of meeting*

Keeping a good record of discussions held during project meetings and any telephone conversation is an essential to be a successful practicing engineer. In order to create habit of taking good notes, each group is required to assign one person in a group to take minutes of the meetings and prepare the minutes to be distributed to other team members. The minutes include date, place, day, and time of the meeting, and items discussed and decisions made in the meeting. The regular minutes of meetings become a part of the final report of the group.

*3.3 Oral presentations*

In today's consulting world, at several occasions the Clients require the practicing engineers to present their proposals and final designs. On large projects, the project team may consists of several consulting firms and more than one engineer from each firm. In addition to the technical contents of the proposal or a project, the quality of presentation of a team is an important factor in getting a project and/or defending the design. Therefore, at the end of each semester, each group orally presents the proposal or report. Each student presents his/her part of the proposal and project. All oral presentations are formal and made with presentation software "PowerPoint ©" or any other similar software. Final presentations are open to everybody interested. In order to prepare the students for presentations, during the middle of the semester students are required to go through practice presentation. Only project advisors attend the practice presentations.

*3.4 Role of the instructor*

The instructor serves the role of a Principal of the design firm. The Principal is responsible for defining the project, providing guidance in development of the scope of work, and reviewing the final proposals and reports. The Principal acts as liaison between the design team and the Client.

*3.5 Role of team members*

Each student in a team plays the role of a design professional/engineer in any one area of civil engineering, e.g., geotechnical, environmental, hydraulics, structural, surveying etc. Each team works under the guidance of the Principal. The role of the design professional is to develop scope of work, cost estimate, proposal, basis of design, limitations etc. for his/her part of the proposal and finally design his/her part of the project by getting input from other team members, and providing them assistance to successfully complete the project.

**4. Involvement of practicing engineers**

By teaching how theory is applied in practice, and importance of communication and teamwork, undergraduate become better students and eventually better engineers [3]. Industry can help engineering programs by providing practical experience, presenting seminars and workshops, and working with students on their projects to ensure that the graduates are strong in critical non-technical areas identified by ABET. At Southern Illinois University - Carbondale, practicing engineers are involved in the Civil Engineering Design course in two ways (1) by serving as technical advisor on the projects, and (2) by inviting them for presenting seminars on the topics related to the course contents and open discussions with the students. A brief discussion on seminars and ITAs is presented below.

*4.1 Open discussions and seminars by practicing professionals*

The department of civil engineering at Southern Illinois University - Carbondale, organized a series of seminars primarily for the Civil Engineering Design course. Since the deliverables for Part A of the course is a formal proposal to complete the design of a project, a series of seminars was organized in Fall 1999 on the process of proposal development and key elements of proposals prepared by different practicing professional. The topics of the seminars included proposal development an architect's perspective, a structural engineering consultant's perspective, a general contractor's perspective, a geotechnical engineering consultant's perspective, a surveyor's perspective, and a researcher's perspective. Other seminars on technical topics organized during Spring 2000 included innovations in

foundation construction, steps involved in structural design of a real world project, and cost estimating for project construction bidding. The seminars were presented by principals or senior professionals of the practicing firms.

Each of the speakers who presented seminars on proposal development was requested to include a sample proposal and cost estimate to perform their part of services for a hypothetical project to establish continuity between the seminars. The hypothetical project consisted of the construction of a two-story, office building with a footprint of 20000 square foot in downtown, Carbondale. Handouts of typical proposal and basis of cost estimate were made available to the students. Students had the opportunity to discuss the details of proposal and design processes of typical projects.

It is well understood that in today's professional practice world, direct or indirect marketing, maintaining efficiency and quality of the work, and developing and maintaining Client relationships are integral part of an engineer's regular assignment. Therefore, in order to introduce these topics to the students the following seminars were organized.

- Marketing tips - selling your self or your firm to a Client, presented by a professor from the marketing department at Southern Illinois University - Carbondale.
- Business of consulting, presented by president of a leading mid-size, geotechnical engineering consulting firm
- Introduction to Total Quality Management (TQM), presented by senior vice president of a leading mid-size, material testing and geotechnical engineering consulting firm

*4.2 Industrial Technical advisors*

Each design group is assigned a faculty member as a project advisor. In addition to the faculty advisor, industrial technical advisors are assigned to the groups as desirable. The students work in groups under the supervision of the faculty advisor and industrial technical advisors. Actual data available for the project is provided to the students and are used in the design of the projects.

**5. Evaluation of Students**

The course contents of a capstone design course are significantly different from other regular courses in which students go through a set syllabus and work on problems which have definite answers. Because of the nature of course contents, grading students for their work becomes a challenge. Since the objectives of the capstone design course is to train students in how to successfully complete his/her portion of the project while working as a member of the design team, the students' performance in the course is judged based on individual performance in completing his/her part of the project and his/her interpersonal relationship with other team members.

At Southern Illinois University - Carbondale students enrolled for Civil Engineering design course are evaluated by a team of at least three official judges. Judges evaluates the teams as well as individual students. In addition, other students and guests attending the presentations evaluate technical and non-technical work of each team. The team members of a group are also given opportunity to evaluate their teammates in order to identify the individuals who fell short in performing his/her work in a professional manner. Final grade of each student is calculated using the grading distribution given below.

*Grade Distribution*

| | | |
|---|---|---|
| Final Written Proposal and Plans - Individual Effort | 20% | |
| Final Written Proposal and Plans - Group Effort | 20 %* | |
| Oral Presentation - Individual Performance | 15 % | (Evaluation by Judges) |
| Oral Presentation - Group Performance | 15 %* | (Evaluation by Judges) |
| Evaluation of Oral Presentations by others | 10% | (Evaluation by Audience) |
| Confidential Evaluations by other Team Members | 10 % | |
| Homework Assignments | 10% | |

* Each group member is given the same grade for these items

## 6. Conclusions

An overview of how the participation of industry in the capstone design course at Southern Illinois University - Carbondale has been initiated is presented. The recent changes made to disseminate information using practicing engineers, has enhanced the students' understanding of the course contents. Additional input from the graduating students is being collected to further improve the course.

## 7. References

[1]. Wankat, P. and Oreovicz, F. Teaching a problematic subject. Prism, ASEE, November, 1999.

[2]. Kumar. Integrating industry and technology into civil engineering curriculum. Proceedings of the 2000 Spring conference, North Central section, ASEE, March, 2000.

[3]. Wankat, P. and Oreovicz, F. Industrial Role Models, ASEE, January (2000).