2006-1930: INTRODUCING PROJECT MANAGEMENT TO SENIOR CIVIL ENGINEERING STUDENTS

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Introducing Project Management to Senior Civil Engineering Students

Abstract

The Civil Engineering program at the University has a senior capstone project that requires students to seek out actual design projects. Many of these projects are done in conjunction with practicing professionals and ultimately student work becomes the preliminary concept for final development.

Recognizing that the creation of a capstone project is not effectively completed within one semester, Civil Engineering split the project into a two semester offering. The first semester concentrates on developing Project Management skills. Up to the senior year, most of the students meet the requirements of the program through technical training and work on electives as allowed in the program structure. The "softer" engineering skills do not tend to be part of the process.

Project Management is taught in three segments through the semester that leads to the capstone project. First, students are introduced to overall project management concepts such as project success, organizational structure, and team work. Second, students learn basic information on cost estimation, scheduling, and economic constraints. Last, students form project teams and develop a preliminary proposal for concept of the capstone project. The student teams present these proposals to the civil engineering faculty who judge the proposals on merit. The feedback and assessment allows student teams to build and structure strong concepts to better execute the preliminary design process.

The project management introduction has been implemented for three consecutive years and ultimately student capstone projects have continually improved. Capstone projects are showcased at the annual on campus state section of the American Society of Civil Engineers meeting. Practicing professionals have commented on the excellent quality of the capstone projects.

Introduction

The Civil and Environmental Engineering (CIE) Program at the University is an ABET accredited program that offers students technical coursework in the major traditional areas of Civil Engineering: Environmental, Geotechnical, Structures, Transportation, and Water Resources. In addition to the traditional introductory CIE courses, students take both technical electives to supplement their Civil Engineering specialties and humanities electives for a rounded engineering education. Through the encouragement of the Industrial Advisory Committee (IAC) that works with the CIE Program, CIE adopted a two credit hour course in Project Management that is required of all senior Civil Engineering students. CIE 413 was developed to introduce students to the concepts of project management that are not usually addressed in technical coursework. The CIE curriculum requires students to work on a capstone course during the spring semester of the senior year. CIE 412 is the engineering economics course that is taught concurrently with CIE 413 during the fall semester of the senior year. CIE 411 is the capstone

course that is offered in the spring semester of the senior year. In the last two academic years (2004, 2005), CIE 413 introduced students to project management tools and preliminary proposals in the fall semester and CIE 411 developed these preliminary proposals to final capstone projects consisting of presentations to clients, plan development, and marketing materials.

This paper will discuss how project management tools are introduced to civil engineering students and how these skills are utilized in developing the preliminary capstone proposal.

Background

The development of CIE 413 Project Management was based on several TC2K/ABET criterion 2 objectives. Each of these objectives helped formulate the strategies used to present project management topics in both active and reflective learning methods. The objectives that were applied included:

a. demonstrate an appropriate mastery of the knowledge, techniques, skills, and modern tools of their discipline,
b. apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology,
d. apply creativity in the design of systems, components, or processes appropriate to program objectives,
e. function effectively on teams,
f. identify, analyze, and solve technical problems,
g. communicate effectively,
h. understand professional, ethical, and social responsibilities.

The course was structured through a combination of lectures and group exercises into three distinct modules of study. Because of the limited time assigned to the class meeting period and the large number of students, the exercises had to be abbreviated to allow individual participation. Students self-selected work groups to ultimately prepare a capstone project. These groups began their efforts within CIE 413 to develop the preliminary engineering capstone proposal.

Module 1

Under the first module of the course, students were introduced to basic concepts of the design process, organizational structure, and the politics of project management. The intent of this area was to meet ABET objectives b, d, f, and i. The course began with the discussion of engineering failure and engineering success. The criteria used for judgment of success or failure was defined as on time delivery, on budget, and within technical goals established for the project. Students were assigned to read two papers about engineering failures: failure of the Tacoma Narrows Bridge and failure of the Edsel automobile. Since students had taken structural design courses, the failure of Tacoma Narrows Bridge was fairly obvious to them as the failure of structural elements and the effects of vibration. However, the failure of a project due to the political environment was not as obvious. Since most students could relate to automobiles, the discussion about the Edsel opened up the dimensions of politics and technical goals. Three automobiles of

the past were discussed: the Tucker, the Edsel, and the Corvair. 1:18 scale models of these automobiles were passed amongst the students to show what each automobile looked like. Videos of time era commercials of these vehicles were shown in class to illustrate what the public saw during the time. The discussion then progressed to illustrate politics. The Tucker demonstrated how a project can go bad due to unachievable goals and poor finances. Though appealing, the Tucker Company could not technically meet the promised features for the automobile and could not maintain a cash flow for production. The Edsel demonstrated how a project can go bad due to poor marketing and public resistance. Though heavily marketed with commercial glitz, the Ford Motor Company disregarded the information collected through focus groups and surveys. Management was not fully supportive and soon the product was withdrawn from the market. The Corvair demonstrated how a project is affected by outside forces such as regulation. Though the Corvair became a popular automobile, safety advocates demonstrated major concerns that forced General Motors to discontinue production. The Corvair also illustrated how unconventional ideas used in a design often can cause resistance from both the customer and management.

Organizational structure was presented through typical structure diagrams depicting traditional internal company structures. The discussion presented the concepts of functional and matrix organizations to illustrate how line and function may be different within an organization. Most of the students go to consultant engineering firms and will see the varied organizations. Under the organizational structure presentation, students also discussed the three main parties involved with a project as the owner, engineer, and the contractor. External relationships of these three parties was discussed along with the variations in the chains of command and communication structures for the parties. New concepts such as design-build and innovative contract procedures were discussed as forms of fast track design.

The politics of project management was illustrated through discussing the environment of a project. An active learning exercise used in class included a small group activity where students were given 20 minutes to develop a conceptual design for a strip mall. After the design exercise, groups were given an additional 20 minutes to list all of the interest groups that could potentially be involved in the project. Collectively, the groups identified most of the major regulators and special interest groups involved in projects. After the stakeholder discussion, personality types were introduced. Personality was discussed through research on individual's time and place of birth. Students then took a personality indicator test to see what areas of interest each student had. Collectively, students were categorized into the personality indicator traits. Through a show of hands, students saw how they related to their respective peers. Interestingly, the class of 2006 tested with more social skills than normally associated to engineers. After this exercise, team building was illustrated through an active learning exercise with teams building spaghetti towers. Self selected teams were given dry spaghetti and miniature marshmallows. The teams were given 25 minutes to build a vertical tower using the assigned materials. Individuals on the team could only use one hand at a time to force interaction to hold materials and build the tower with team mates. The object was to get the highest tower. The activity illustrated the importance of planning out how the project needed to be developed and the importance of team work to complete a project.

Figure 1- team members build a spaghetti tower using one hand with fellow team members.

Module 2

The second module of the course consisted of introducing analytical tools to students for project management. The intent of this area was to meet ABET objectives a, g, and i. Students had developed technical engineering skills, but did not know how to determine if the technical ideas were feasible as applied to cost and constructability. Simultaneous to taking CIE 413, students took CIE 412 Engineering Economics. In CIE 412, they were shown the time relevance of money, but had not used these concepts to make decisions about viable alternatives.

The second module began by introducing students to reading plans and specifications. Both heavy civil and building plans were shown in class and the differences between these plan types were highlighted. Specifications for both types of projects were also discussed and differences were shown through example using the descriptions for a catch basin as presented in each type of specification. Next, project estimating was introduced. Students were shown how to extract information from the RS Means Heavy Construction estimating guide. A miniature set of plans was distributed and explained in class to illustrate how to do quantity take-off. Students knew how to design the information depicted on the plans, but had not yet determined how to quantify a plan. A class exercise was distributed and students were asked to estimate the cost of the class exercise working within their capstone teams. Students were shown how to estimate using a unit pricing method.

The last project tool introduced was project scheduling. The basic activity on arrow technique was shown. A practice exercise was done in class and groups compared their answers. A take home test was given to students that covered the areas of project estimating, scheduling, plan reading, and project alternatives selection. Students were given a set of miniature plans and

selected pages of specifications. The test required a series of short answers based on the plans. There were several item numbers given and the student needed to go through the plans and identify the items, the quantities, and generate an appropriate cost. The student then had to develop a quick schedule for these items. Obviously, students chose to work together and the average test scores were quite high. The purpose of the take home was to get students to learn how to use plan sets and to work with one another to interpret the results.

Module 3

The final module of the course was to develop a preliminary proposal. Students were shown some of the information presented in a typical preliminary engineering proposal. In conjunction with the requirements in the CIE 412 class, students searched for possible engineering projects that required engineering work that could be used in a capstone project. Capstone teams submitted a brief paragraph about the possible project along with contact information and team member resumes. These projects were evaluated for feasibility and instructor comments were provided on possible considerations for the project. A second draft of the proposal was then prepared that included additional information about specific design considerations and refined scopes of work that could be performed for the capstone. Again, instructor feedback was generated. The capstone teams then presented the concept to their class peers in 5 minute oral presentations. Peers were given evaluation forms for feedback to the individual capstone teams. The teams revised the proposals based on this feedback. A third preliminary proposal was then prepared to refine the actual proposal based on better project definition and the feedback from instructors and peers. The individual capstone teams then presented their final proposals to their peers and a team of Civil Engineering faculty members. Peer and faculty evaluations were based on a standard form that critiqued both presentation style and technical merit of the project. Peers and faculty asked questions of team members during the presentation. All of the three feedback forms along with overall rating information were then compiled for each team and a general grade was assigned. The evaluation information reflected the three stages of proposal development and evaluation from both peers and faculty. The evaluation form is shown as Exhibit 1 in the appendix.

Conclusion

The implementation of a project management course within the Civil Engineering curriculum has worked well at the University of Maine. Students are introduced to basic management principles and the factors that determine engineering success and failure. They are exposed to the concepts of managing people to supplement the technical skills that they have learned. They are taught some of the project tools needed to present the engineering project to the client: budget and schedule. They are shown what information is used to build the project through plans and specifications. They then develop a preliminary engineering proposal to form a clear understanding of a project to complete within the capstone design. The engineering feedback provided on the proposals simulates the type of real feedback that future clients may give to an engineering firm in the process of putting together a project.

The development of the project management course is best created in conjunction with ABET objectives. These objectives help formulate the learning outcomes that should be expected from

graduating seniors in a civil engineering program. The use of organization, project tools, and proposal development simulates the environment in which consultant engineers work. The development of project management skills helps students to better understand the senior capstone project.

The course has been offered during the fall semesters of 2004 and 2005. A follow up survey will be administered to students at the end of the capstone project in spring 2006 that will assess the merit of the proposal stage introduced through CIE 413. Anecdotal evidence suggests that the preliminary proposal and project management class has helped students with the capstone project. Several students have commented that the preliminary proposal development through CIE 413 has helped in preparing the ultimate capstone projects. Faculty has commented that the projects are stronger and better organized with the preliminary process. Earlier projects tended to be difficult to prepare and lacked thorough development. The quality of the project definition and ultimate presentation is improved.

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Exhibit 1

Rating for Capstone Projects:

Team
Members_____
_____
_____

Title of Project_____

1. Using the following Matrix, 1 is low and 5 is highest, how would you rate the team:

Traits	1	2	3	4	5
I understood what the team proposes to do.					
All members seemed to equally contribute.					
The presentation materials were appropriate.					
The project that was presented is feasible.					
The team seems to have reasonably thought about potential options.					
This proposal is worth developing.					

2. Suggested changes:

   a. _____
   _____

   b. _____
   _____

   c. _____
   _____

3. Other considerations:

   a. _____
   _____

   b. _____
   _____

   c. _____

Overall, how would you rate this proposal and presentation: _____Good _____Fair _____Poor