2006-1438: COMMUNICATION IS ENGINEERING: RESPONDING TO NEEDS OF INDUSTRY IN A CAPSTONE COURSE

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Communication IS Engineering:
Responding to Needs of Industry in a Capstone Course

Abstract

Research has shown that consulting engineering firms need newly graduated junior engineers to be skilled in communication, especially writing. In response to this plea from the civil engineering industry in Salt Lake Valley, University of Utah has designed a capstone course in its Department of Civil and Environmental Engineering that focuses on written, oral and team communication besides technical and design elements. The course incorporates communication instructors from the CLEAR program who collaborate with faculty, lecture in the class, consult with students and assess assignments in an effort to ensure a higher level of communication competency in graduates.

Introduction

Undergraduate curriculum capstone courses in Civil and other engineering disciplines attempt to fulfill a host of objectives. Most notably, they incorporate design projects and teamwork to fulfill specific criteria of the Accreditation Board for Engineering and Technology (ABET). They provide their students with an opportunity for synthesis, employing the technical skills they have learned in the program, and introducing elements of professional practice that will ease their integration into industry after graduation.

In order to meet the needs industry has for young engineers, many universities have incorporated mock corporate environments and real-world clients into the capstone course. Besides familiarity with a team work environment and real clients, preparation for professional work in the field of civil engineering requires extensive practice writing and presenting engineering reports. This paper will present research exposing industry's need for junior engineers with higher levels of communication skills in Salt Lake City, as well as University of Utah's (U of U) program created to fill that need. Specifically, it will examine the Professional Practice and Design capstone course in the Department of Civil and Environmental Engineering, which incorporates an innovative, interdisciplinary approach to engineering and communication education. This approach involves a partnership between the department and consultants from the U of U Center for Engineering Leadership, funded by the CLEAR grant (Collaboration, Leadership, Ethics, And Research).

While finishing their graduate degrees in Communication, Rhetoric and Composition, and English, these consultants collaborate with Engineering faculty to develop and implement written, oral and teamwork communication education in various departments within the College of Engineering. In the Civil and Environmental Engineering department, faculty and consultants have developed a capstone course intended to provide students with a unique opportunity to learn and practice written, oral and team communication in a simulated professional firm environment. They produce and present a Proposal, Feasibility Study, and Preliminary Engineering Report with 75% drawings and specifications for their community client, making the course a design, communication and professional practice intensive experience.

The Civil Engineering Capstone Experience

The importance of writing skills is widely recognized[1]. Because up to "half of an engineer's time can be spent on written communication and most everything an engineer does needs to be documented in writing"[1] , industry leaders agree that writing skills need to be addressed in capstone courses, though written and oral communication are not part of the traditional engineering curriculum. In her interviews with industry leaders, Sundy Wantanabe, a Writing Consultant at the Center for Engineering Leadership, found that Salt Lake City engineering firms have very specific needs concerning communication abilities in their junior engineers. Dale Smith of APCO, Inc. complains that new engineers largely have grammatical problems and are unfamiliar with the documents they are expected to produce[2]: technical proposals, letters of scope and transmittal, reports, and users' manuals. His firm needs young engineers with the "ability to write for a lay or technical audience," convey concepts clearly, conduct team activities and "process" lab reports, which entails writing lab reports besides conducting experiments. Michael Busch of BNA Consulting[3] and Bruce Korth of CC&E[4] add tone sensibility in email communication and good interpersonal abilities with clients to the list of necessities along with AutoCAD and MS Office familiarity.

Industry and academic sources agree that Engineering design courses need to do a better job of "imparting skills which have not often been associated with traditional science-based education"[5]. Creative ways to effect the needed changes in engineering education must be undertaken. In order to accomplish this change, many universities adopt a real world atmosphere to close the gulf between "practicing engineering and studying to be an engineer," thus bringing students closer to real engineering practice[6]. Students in these programs experience not only the design process, but are exposed to the type of business atmosphere and communication skills they will encounter after graduation.

As most design courses, the 4910 Professional Practice and Design, single-semester capstone course in the Civil and Environmental Engineering Department (CVEEN) has evolved over the years[7]. Beginning over a decade ago, the course now includes community clients, industry consultants, specific written deliverables and formal presentations. Each semester the course holds 20-30 students, representing various emphases within civil and environmental engineering, who are separated into three to five person teams. Each team studies and provides discussions, drawings and specifications for a portion of the overall project design. The project management team leads the other teams in major decision making, acts as a liaison between the teams and the client, compiles the written reports submitted by the teams, and generally works closely with faculty to oversee the entire project.

The type of project required of the students has been honed so that, now, faculty chooses a project in Salt Lake Valley each semester, along with a community client and industry liaison. The course generally focuses on projects that will be of benefit to the local community. Reports are presented throughout the semester to local members of the civil engineering and construction community in Salt Lake Valley as well as other government and private agencies at three invitational gatherings: one for the proposal, one for the feasibility study, and one for the engineering report based on chosen alternatives from the feasibility study. Past projects have involved a footbridge over Wasatch Blvd. joining student housing with the university campus, a

rail trolley line connecting the Sugarhouse shopping district to the TRAX light rail line, a bike lane up Big Cottonwood Canyon just southeast of Salt Lake City, and a portion of the Utah State Capitol Master Plan including a subterranean traffic tunnel.

For each of these studies, key contacts at the Department Of Transportation, Utah Transit Authority and various local developers and civil engineering firms formed a consultation team who represented the course "client" and/or made certain resources available to the students. The contacts are chosen and contacted before each semester by the professors in charge of the course, who are scheduled on a rotating basis, usually the same semester each year. The instructor thus becomes, as Dr. Lawrence Reaveley (chair of the department and head 4910 instructor) puts it, a sort of "coach"[8], who brings together a comprehensive team of industry and faculty instructors who speak to the class on various professional practice issues, such as quality based selection, financing, and project management.

While the CVEEN Professional Practice and Design course includes many of the course components common to other universities, its unique emphasis on engineering communication education distinguishes it from other universities' programs. The department has responded to the plea from Salt Lake Valley consulting firms, like APCO, BMA and CC&E, who have voiced their desires for junior engineers with professionally developed writing and communication skills. The course now emphasizes written, oral and teamwork communication skills throughout the semester. A unique collaboration between engineering and communication instructors makes this emphasis possible.

CLEAR Engineering

The partnership between communication professionals and engineering faculty actually affects the students' curriculum beginning in the freshman "Introduction to Civil Engineering" course and continues in the upper division technical communication course before culminating in the capstone class. The four year plan was developed through a collaboration between the engineering faculty and CLEAR consultants and is based on the conclusion that when students come to senior design with pre-developed skills in teamwork, writing, oral communication, and design processes, they leave the department "more employable"[9]. Students entering senior design with little or no experience in these areas will need to learn them, forcing them to learn by "producing" rather than "practicing"[10]. When students must learn how to write documents, be responsible for determining and testing design alternatives, interact with clients, and produce three reports and presentations all in one semester, the opportunity to practice their skills diminishes. At U of U students have already been introduced to all the document types, have worked in teams, and have presented reports in at least two courses before entering the capstone course.

To better help students learn to produce professional documents, the course schedule (see appendix A) includes a deadline for the submission of document drafts at least a week before their presentation. The students' drafts are reworked by a "revision team" comprised of students from various teams in the class. Often, assessing individual students' contributions and competence in a mock corporate team environment is the most problematic grading issue instructors encounter in engineering capstone courses, as it can be difficult even to assess which

students have been "exposed to instruction and feedback on specific areas of competence"[10]. In order to ensure that each student takes part in the writing and revising process during the semester, each student is required to participate on the revision team once during the semester. Thus, 7-10 students from different teams comprise the revision team for each report.

The revision team is guided by the technical Teaching Assistant (TA) and the CVEEN CLEAR Writing Consultant who read through the drafts and make recommendations to the team for revision. This process allows the students to collect their data, formulate their design, and then construct a report that best conveys their work, with the assurance that their decisions will be reviewed by instructors before the final version is submitted to the client and faculty for grading. By giving the students time to create a draft version of their reports, instructors ensure that they use precedent and critical thinking skills to organize the best report format they can rather than working from a predetermined template. The students are responsible for constructing the report this way, rather than filling in an outline penned by a book or an instructor. The iterative process common to engineering design becomes the same iterative process students use to produce their reports.

This system requires the Writing Consultant and technical TA to spend hours reviewing the drafts and consulting with the revision team. While it takes more instructor time, this process results in greater student involvement in the writing of the reports. It requires committed communication consultants who become truly hybrid instructors, spending multiple semesters and even years working in the same courses. Student resistance to drafting and revising can be strong, but being frustrated and working through problems is part of what the professional practice course is all about. If students got everything right the first time, they wouldn't need to be in school. As Reaveley points out, "if the students aren't upset along the way by revisions and by demanded changes on the client's change of mind or understanding of what's happening, then I'm upset that the class hasn't worked. I want them to have some frustration"[8]. When students come to class with their PowerPoint slides, ready to practice their presentation, the Oral Communication Consultant reviews the slides and advises the teams on their speaking style and overall presentation. Without the Writing and Oral Communication Consultants, faculty would not be able to devote the time to commenting on multiple iterations of the reports and presentations. In this way, the CLEAR Consultants have become integral to teaching Civil and Environmental Engineering at University of Utah.

These communication consultants are currently funded through the CLEAR grant administered by the Center for Engineering Leadership. The CLEAR grant is currently in its third year of a five year plan, at the end of which the benefiting departments will adopt financial responsibility for one of the two consultants, and the other after another two years. The center is currently petitioning the university for perpetual funding.

Conclusion

Prepared by the communication and design thread in the Department of Civil and Environmental Engineering, capstone students enter the course ready to tackle the multiple tasks they will need to execute in order to produce the required deliverables. Often, these students must conduct community focus groups, communicate with industry specialists and clients, produce drawings

with various software programs, and record inter and intra team communication in memos and log books, besides preparing reports, presentations and attending lectures on practical professional practice issues. Thus, the major focus of this course really falls on multitasking. Reaveley states "everybody has to learn some aspects of multitasking; the students have to multitask between their course loads. They've got an obligation here, and here, and here. If they don't learn to multitask they will be limited in their career advancement…when I was running my office, in a month's time I'd work on 25-30 projects"[8]. The goal of the CLEAR and CVEEN 4910 instructional team is to produce graduates who are prepared for a multitasking environment with solid written, oral and teamwork communication skills besides the science and technical training traditionally expected of engineering programs.

Although the program, in its third year, has not graduated any students who have participated in all three communication thread classes, course evaluations completed by students with experience in industry indicate their satisfaction with the program. One student writes, "I enjoyed refining my proposal writing skills. I have been working in Civil Engineering consulting for 11 years. I am required to write 2-3 large proposals as well as a multitude of small proposals each month. The things I've learned about proposal writing in this course have translated to greater success in this area of my career. Additionally, I enjoyed the group aspects of doing work. It is the way things work in the real world"[11]. Another admits, "It was difficult for me to be critiqued by English students since I have never been conscious of my grammar and writing skills when writing reports, but these are valuable things for me to consider, and they will undoubtedly help me in my future"[12].

The integration of Communication professionals into the teaching staff of the College of Engineering is one solution to the demands of industry. Their focus on professional issues and the extra time they are able to spend coaching engineering students and collaborating with faculty result in greater resources for student learning. Students who have worked in industry and know its demands seem to be the most appreciative of the program, as one points out, "the ability to discuss any questions pertaining to proper presentation skills and what to include in a paper or report at any time is very helpful. I feel that I can speak for my peers and say that we could not have been given any better assistance in this class"[13].

The partnership that the CLEAR program has inspired between communication instructors and engineering faculty has benefited both sides. The engineering department is able to introduce communication specialists into their instructional staff, and the consultants themselves are able to practice their teaching methods and material while learning about an admittedly foreign discipline. The program results in hybrid instructors whose niche grows and gains a stronger place in the College of Engineering with each passing semester. Members of the program and the departments in which they consult agree that their interdisciplinary instruction allows students to benefit from the expertise of specialists in multiple fields and produces more well-rounded graduates, better prepared for the workplace.

Industry leaders continue to name better writing skills as their one wish for interns and junior engineers. Even Dr. Reaveley admits, "I don't know what we'd do without CLEAR involvement in our courses"[8]. As curriculum designers continue to incorporate writing and speaking skills into their engineering design and professional practice courses, the long pathways between

colleges begin to shorten, exposing the inseparable liminality between the disciplines, and revealing the fact that Communication truly is Engineering.

Appendix A

CVEEN 4910 Course Schedule

Class No.	Date	Class Topics	Class Workshop Activity[A]	Deliverables[1]	Pre-Reading Assignment - Quiz Material	a-k item	Lecturer
1	10-Jan	Course Introduction, Project Description and Management Requirements, Owner's requirements, Note Taking and **Journals**. Team Structure & Team Assignments.[4] Site Review. The Design Process and Team Interdependence.				c, n, d	LDR/ Tyler
2	12-Jan	Work shop (Project overview and scope?)		Project Vision Statement[3]			
3	17-Jan	Proposal Basics. Progress Report Requirements[5]. Preparing memos and follow-up. What's an SOQ? RFP? Feasibility Study? The Project Process. Use of our Class Web Site. The Seven Habits.	What tasks will you be required for you to complete the project.	What will it take to accomplish your vision?[6]	Text: Chapter 2 and pp 441-448		LDR/ Tyler/ Jenn
4	19-Jan	Work shop (Project requirements and alternatives?)		Individual Resume's[2,7] (Printed copy and electronic version)	Text: Chapter 4	c, g, k	
5	24-Jan	Project Scope: Individual Team Scope Development. Team time budgets. Writing technical reports. Contents and format of report. What are you conveying? Review of submitted Resume's		Team Definition of the Problem /Scope/ Time Budget[8]		g, h	Jenn
6	26-Jan	What is a Proposal? What should a proposal include? Presentations-a lot more than talking about your "numbers".?	Present your team qualifications .	Submit revised individual resumes	Text: Chapter 3	g	Jenn
7	31-Jan	Marketing of Professional Services: Qualifications, proposals and presentations.		Team/Company Resume's[9]		b, e	LDR
8	2-Feb	Project Scheduling and Tracking, Assessing Progress. (Presentation slides due)	Brainstorm alternatives and present preliminary list.	**Presentaion Slides Due Draft Team Proposals Due[10]**	Text: Chapter 14	g	
9	7-Feb	Revision team meeting. Practice Presentations.			Text: Chapter 5	d, k	
10	9-Feb	**Presentations of Team Proposals**		**Final Team Proposals[11]**		g, h, l	

11	14-Feb	Feasibility Study Components - Concepts, Data and Analysis, Risks, Costs and Benefits. Alternatives. Criteria. Preliminary development of alternative solutions.				c, e, h, m	LDR
12	16-Feb	Construction Documents (Drawings, specifications & shop drawings)		Team Alternatives[12]	Text: Chapter 7	c, f, g	LDR
13	21-Feb	Cost Estimating - Levels of Detail, Techniques, Sources of information, Risks and contingency	Provide preliminary list of cost elements in each alternative			a, k	LDR
14	23-Feb	Economics. Life Cycle Costing/Value Engineering		Preliminary sketches and drawings[13]	Text: Chapter 8	c, h, k	Mughal
15	28-Feb	Ethics. Codes of Standard Practice.	Discuss a potential ethical conflict for your team in this project.		Text: Chapter 12	f, h, l	LDR
16	2-Mar	Engineering and its relationship to Sustainable Development	What does "sustainable development " mean to you in this project?			c, d, g	Eckhoff
17	7-Mar	Team Work Day - Feasibility Studies and Intrateam Coordination		Sustainability, Societal impact and non-economic impact of alternatives[14]		g	
18	9-Mar	Selection of a Consulting Engineer: QBS vs. Bidding. Basis of Design Review. [18]	Provide preliminary basis of design elements for your team.	Preliminary cost analysis of Alternatives[15]	Text: Chapter 13	f, h	LDR
-	14-Mar	Spring Break					
-	16-Mar						
19	21-Mar	Safety.	Discuss safety elements your team should consider.	**Draft Team Feasibility Studies[16]**		f, h, i, j	
20	23-Mar	Team Work Day - Feasibility Studies and Intrateam Coordination				d	
21	28-Mar	**Presentations of Team Feasibility Studies**		**Final Team Feasibility Studies[17]**		b, d, g, n	

22	30-Mar	Selection of Preferred Alternatives. QA, QC and the Review Process. Specifications.	How will your team ensure quality?	50% Working Drawings[18]	Text Chapter 6	c, f, g, l	
23	4-Apr	Preliminary Engineering Reports. What to include, How they should be written.		Basis of Design (Final)[19]		k	Jenn/ Tyler
24	6-Apr	Final Cost Esitmate (Team Working Session)		Design Calculations[20]		a, h, k	
25	11-Apr	Financial Realities - Charging, billling, and collecting your fees for Professional Services. Basic cost of doing business: overhead, taxes, etc. Fixed fee vs. Cost plus bidding.		Final Specifications[21] Engineering Estimates[22]	Text: Chapter 10	f, g, I	
26	13-Apr	Alternative dispute resolution: A Model for Life. Arbritration.		**Draft Final Engineering Documents - 75% Design[23]**	Text: Chapter 11	g,i,	Jenn
27	18-Apr	Organizing your professional life - Tasking, Prioritizing, Scheduling and Coordinating while maintaining a balanced personal life.	What are some personal goals? How will you work to achieve them? (voluntary)		Text: Chapter 15	f, g	Eckhoff
28	20-Apr	Team Work Day - Preliminary Engineering Reports & Intrateam Coordination		**Second Draft Final Engineering Documents - 75% Design[24]**		f, h	
29	25-Apr	Professional licensing. Student Feedback Day - Critiquing of the Course. Practice Presentations				f, i	LDR
30	3-May	**Final Exam Day. 8:00 to 10:00 AM as scheduled (AT THE CAPITOL!!!). Presentations of Team Preliminary Engineering Reports**	-	**Revised 75% Engineering Documents[25]**		a, b, c, d, e, f, g, h, j, k, l, m, n	

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