AC 2011-676: 100 FRESHMAN CIVIL ENGINEERS: A MODEL FOR INTEGRATING COMMUNICATION AND TEAMWORK IN LARGE ENGINEERING COURSES

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100 Freshman Civil Engineers: A Model for Integrating Communication and Teamwork in Large Engineering Courses

Abstract

Engineering education has been transformed over the past decade. Increasingly, engineering students are seeing the integration of communication, teamwork, leadership, and ethics into their engineering curriculum. The best models are those that couple these professional skills with actual engineering projects to show students how intricately linked communication and teamwork skills are with engineering problem solving and design. Much emphasis is placed on senior capstone courses, as this meets the immediate demand of preparing graduating seniors for the non-technical aspects of their careers. In contrast, freshman classes receive less attention in terms of their position to "set the tone" for the coupling of communication and engineering, likely because the demands placed on freshman engineering classes are already high. They serve as a recruitment tool, pique interest in engineering, expose students to the many and varied areas of concentration in the discipline, and perhaps, introduce students to engineering projects and basic design skills. While the many and varied objectives of freshman classes already challenge the curriculum, increasing enrollment is another constraint. Unusually large freshman classes make intensive speaking and writing opportunities challenging in terms of evaluation and feedback.

We have successfully integrated communication and interpersonal skill development into the freshman civil engineering class for several years. Despite many years of success with this course, we faced a unique challenge this year when enrollment increased by almost fifty percent. This increased number of students threatened to disrupt our already intensive instruction and evaluation processes.

Our purpose in this paper is to showcase our unique approach to team teaching, illustrate the individualized attention students receive on their writing, speaking, and teamwork assignments, and provide an assessment of our approach. Specifically, we highlight our model of team teaching, and show how we capitalize on a unique class structure to allow for individualized communication experiences and feedback for all 100 students. Finally, we assess our efforts through gathering student feedback in the form of surveys, evaluating students' speaking and writing competence, and gathering feedback from the instructional team to guide continuous improvement in the course.

Background

Industry and accreditation boards agree that the emphasis placed on technical skills, though necessary, is not sufficient to preparing students for the transition from school to workplace. The Accreditation Board for Engineering and Technology's (ABET) Engineering Criteria 2000 revised the criteria for evaluation to include (among other outcomes) an ability to function on multidisciplinary teams and an ability to communicate effectively.[1] In order to prepare engineering students for their future as professionals, several approaches to teaching have been employed. These include requiring completion of a technical writing course, participation in writing/speaking across the curriculum programs, integrated communication/engineering

courses, and integrated communication/engineering programs.[2] In addition, many universities also have writing/speaking/communication centers that serve to provide individual tutoring to engineering students working on writing or speaking assignments. Most also offer resources to faculty and students alike, including tips on how to complete a writing or speaking assignment, as well as tips on how to evaluate said assignments.

More and more, engineering programs are moving toward interdisciplinary collaboration in the form of integration, whether it be courses, programs, or somewhere in between. However, a national survey of the Civil Engineering curriculum shows that integration of the liberal arts in this discipline are still uncommon.[3] Moreover, professional skills such as communication, leadership, and teamwork are underrepresented.[3] Yet, communication continues to be an important skill set for civil engineers, one that should be meaningfully linked with course work that builds on a strong freshman foundation.[4] However, much communication and professional skill development is delayed until the capstone experience.

In those cases where communication instruction has been integrated into large freshman engineering classes, instructors often have the luxury of lecture/recitation times plus labs/breakout sessions.[5-8] This allows for more individualized attention during designated lab times where instruction can be provided to 30 students or less. Additionally, group work is common in large freshman classes to both teach students the importance of teamwork and minimize grading. Often, the role of communication in these courses is to equip students with writing and presentation basics to help them navigate the undergraduate curriculum.

In contrast, our integrated communication program incorporates communication, teamwork, and ethics instruction into undergraduate students' required, core classes at the freshman, sophomore/junior, and senior level. We assign two communication instructors (Ph.D. students in communication/composition) to the department to team-teach with an engineering professor in designated courses. We believe in setting the tone for the importance of communication to civil engineering work and start teaching students basic skills in their required introductory civil engineering course. Our approach is unique in that we developed a split-class model to accommodate individualized attention on speaking and writing, in the absence of a lab session. Additionally, we provide each student with a strong foundation by providing them detailed feedback on individual writing and presentation skills before putting them in teams.

Course Objectives

The purpose of this freshman class is to introduce students to the civil engineering discipline (and requisite skills), recruit undeclared engineering majors, and retain those who are already committed to civil engineering as a program of study. The class meets the introduction, recruitment, and retention objectives through utilizing a unique textbook, incorporating guest lectures, and capitalizing on a team learning model.

The course text is David McCullough's *The Path Between the Seas* (1977). This book provides an historical account of the challenges encountered while building the Panama Canal. This ships passage way made it easier to transport goods and people between the western and eastern coast of North and South America. This grand civil engineering project spanned four decades and

involved thousands of workers from all over the world. The book outlines the challenges of engineering this project including equipment management, human resources management, political debates, and large project planning, all issues that civil engineers face throughout their careers.

McCullough's book offers a big picture view of a large-scale engineering project that serves as a case study to introduce students to the discipline of civil engineering. As students engage the text, the events that are taking place offer a starting point for class discussion and teachable moments. For example, the challenge of dirt removal is discussed at one point in the book. To introduce first year students to the problem solving skills they will need, we assign them the challenge of calculating how much dirt will be removed in the building of the canal. We then ask them to offer proposals on what to do with the excess dirt.

The book not only introduces students to technical problem solving skills, it also exposes them to the interpersonal skills and political savvy they will need to cultivate throughout their career. For example, one class period is spent discussing the political debates that occurred in the US Congress surrounding legislation about the canal. The discussion highlights how decisions are made by a variety of people, some of whom are not necessarily engineers. Rather, many civil engineering projects are linked to governmental processes and are political in nature. At the end of this discussion, students write a paper arguing to Congress for the building of either a sea level or a lock canal. Together, the instruction and subsequent paper encourage students to think about how persuasive involvement in the political process will be part of their experience as civil engineers. The story of the Panama Canal, one of the largest civil engineering projects to date, provides students with an engaging backdrop for examining the discipline.

In addition to using McCullough's book, the class features five class sessions that showcase one or two professors to represent the different civil engineering specialties offered in the department. These guest lectures offer basic information about the different civil engineering areas and introduce the students to departmental faculty members. Throughout October and November, guest lecturers provide information on water resources, and transportation, structural, environmental, and geotechnical engineering. After the lecture, the students have an opportunity to ask questions about that particular aspect of engineering and what the classes will be like in that program.

The presentations highlight the most exciting and provocative aspects of the sub-disciplines in an effort to generate student excitement about choosing a program of study. For example, the geotechnical engineering professor uses the geological faults that exist in Salt Lake City to demonstrate the importance of studying geotechnical engineering. As the professor shows the students maps of the city overlaid with maps of fault lines, the students are enthralled and engaged as the geological realities of Salt Lake become apparent to them. Having many instructors from the civil engineering program come to the class as guest speakers gives the students the opportunity to learn about programs that are available to them and connect with a professor that teaches those subjects.

One final aspect of the class designed to enhance recruitment and retention is the emphasis on team learning. In the first week of class students are put into groups of 5-7 people and work with

the same group for the entire semester. The groups work together to complete class activities, calculations, and team projects. Additionally, the group members provide support and feedback as students write individual papers and give presentations. These teams offer a foundation in learning how to work in groups, an important skills set, as they will be expected to participate in team projects throughout their civil engineering education and in industry. Lastly, working in small groups facilitates development of community, both in class and as they progress through the program.

The first class of a new program can be an exciting and overwhelming experience and teaching an introductory class holds many responsibilities including socializing students to a new discipline, providing an overview of the degree program and requisite skills, all while trying to recruit and retain students. Our unique approach includes using a book on the Panama Canal so students can explore the discipline through a case study, having different professors guest lecture on civil engineering sub-disciplines, and finally, having students work in groups in a way that will build shared experience and community that will serve them for the rest of their academic career.

Team Teaching Model

We utilize a unique "spilt session" model of team teaching to accommodate small group interaction between students and the instructor team, specifically, the provision of individualized feedback resulting in increased student accountability. The overall structure of the course is centered on the teamwork of one engineering professor and two communication instructors. Together, these instructors combine large lectures for all 100 students with smaller group meetings of eight students each that include one-on-one feedback and individualized instruction. Specifically, both of the communication instructors are assigned approximately 50 students (or eight teams of five students each). The instructors are primarily responsible for grading both the individual and group work in terms of oral and written communication for their eight teams. The engineering professor is responsible for providing lectures for the entire class, grading several engineering assignments, and providing multiple mini-lectures. These individual duties are integrated into the larger class structure to maximize the amount of one-on-one attention for each student, while maintaining the civil engineering content necessary to meet the course requirements. To accomplish this integration, the course utilizes what we have termed split sessions.

In a split session structure, students spend the majority of class time together in the lecture hall where they are provided information on (1) core engineering principles, (2) the discipline of civil engineering, (3) teamwork skills, (4) basic writing skills, and (5) oral communication skills. At two points during the semester, however, four of the engineering lectures become repetitive. That is, these lectures are delivered twice to give students the opportunity to attend one of two identical content sessions. When students are not in these split engineering sessions, they are encouraged to work on team projects in groups, as well as meet with the communication instructors during predetermined times.

For example, in week three of the semester, the engineering instructor provides a split session class on student programs of study. During this portion of the course, groups are also assigned an

appointment to meet with their communication instructor to discuss team contracts. Thus, groups that are to discuss their team working agreement on the Tuesday of week three would attend the Thursday discussion of the program of study. Identical structural accommodations occur during individual student presentations during weeks 7-9 where students attend one of two split engineering sessions per week and meet in their groups with the communication instructor to give their individual presentations. This split session structure allows for students to receive one-on-one attention in small groups that is ideal for instilling effective oral communication skills, while still receiving the introductory civil engineering education suitable within a larger class setting.

In addition to the team teaching and spit session structure, this course capitalizes on the dual communication instructor model for the final team presentations. During this portion of the course, groups of students meet with one of the communication instructors one class day before their final presentations. They receive individual and group feedback concerning delivery, visual aid use, and structure. This feedback is highly focused and aimed at specific improvements to be implemented for the final group presentation. Students then present their final presentations to the second communication instructor and receive their final grade. Student improvement due to increased instructor feedback was documented and is discussed later in this paper. In short, having two communication instructors allows for increased accountability in terms of oral communication improvement.

Thus, our model of team teaching clearly capitalizes on this unique class structure to allow for one-on-one consultations, individualized experiences, and feedback for all 100 students. Specifically, the split sessions and the effective use of multiple instructors highlight how our structure can be a model for dealing with dramatic increases in freshman level civil engineering students.

Communication Instruction, Activities, and Assignments

This freshman class assumes responsibility for instilling in students the importance of communication and teamwork to engineering. As such, we have students complete both individual and team presentation and writing assignments. Students receive instruction in class, complete communication assignments, and receive in-depth feedback on their communication skills. Table 1 provides an overview of the assignments, instruction, and feedback that students receive in this freshman civil engineering course.

Table 1. Communication assignments, instruction, and feedback integrated into freshman Civil Engineering class

Assignment Descriptions, Instruction, and Feedback

	Assignment	Assignment Description	Instruction	Evaluation and Feedback
Individual Assignments	Contemporary Issues Report	Students choose 1 academic article on a civil engineering issue and write a 2-3 page report that includes the following sections	Communication instructors provide instruction on the writing process, discuss expectations for the assignment, and review the criteria for evaluation	Students receive feedback and a grade, and have the opportunity to revise through attending a writing consultation
	Contemporary Issues Presentation	Students prepare a 5 minute presentation that informs their audience about a contemporary civil engineering issue	Communication instructors provide instruction on organization, delivery, and visual aids, discuss expectations for the assignment, and review the criteria for evaluation	Students deliver presentations in small groups, receive feedback from peers and the communication instructor, and have the opportunity to meet with instructors to view video recordings of the presentation for more detailed feedback
Team Assignments	Team Assessment Report	Teams write a 4-6 page report that assesses the issues of river flooding in the Panama Canal through a comparison of a lock canal and a sea-level canal	Communication instructors provide instruction on teamwork, conflict resolution, and group decision-making, and the engineering professor discusses expectations for the assignment and criteria for evaluation	Teams receive written feedback and a grade, and have the opportunity to revise through attending a writing consultation
	Team Presentation	Teams prepare a 10-12 minute presentation on the status of the Panama Canal project in 1905	Communication instructors provide guidance on team presentation skills including smooth transitions between speakers, discuss expectations for the assignment, and review the criteria for evaluation	Team presentations include a rehearsal session where teams receive immediate oral feedback for improvement for the final presentation, a final presentation with oral feedback, and the opportunity to meet with an instructor to view video of presentation and receive additional feedback

Student Feedback

Overall, feedback indicates student satisfaction with instruction on writing, speaking and teamwork. Students were asked to rate the helpfulness of the writing, speaking, and teamwork instruction on a 1-5 scale, 1 being not at all helpful and 5 being very helpful. Table 2 shows students' ratings of helpfulness of instruction for writing, speaking, and teamwork.

Table 2. Helpfulness of communication instruction to completing class assignments

	Writing Instruction	Speaking Instruction	Teamwork Instruction
Mean	3.43	3.54	3.47
Mode	4.00	4.00	4.00

As shown in table 2, students found the teamwork instruction to be most helpful to completing class assignments, followed by speaking and writing.

We can learn more about this feedback by examining students' open-ended responses to questions about the effectiveness of instruction. Students who found the writing instruction helpful pointed to clear expectations and information about grammar and style as particularly helpful. For others, they saw the instruction as a nice refresher or review to what they learned in high school or their introductory college writing course. Interestingly, those who found the writing instruction not very helpful cited expectations—in this case a lack of clear expectations—and the fact that much of what they learned was review. To improve the writing instruction, students recommended more opportunities for feedback and meetings with the communication instructors, more detailed explanations of expectations/specific instructions, more examples of good writing, and finally, more in-depth instruction on writing.

In terms of the communication (speaking) instruction, students liked that the instruction provided a template for how to give a good presentation (i.e., the instructors practiced what they preached), they appreciated the communication of clear expectations, and they liked the tips on how to organize and deliver a presentation. Only a few students found the speaking instruction less than helpful and these students simply felt like they had learned the information before. To improve the communication instruction, students recommended even more instruction and opportunities to practice.

Finally, with respect to teamwork, students found it very helpful because it taught them how to communicate effectively and how to cooperate with their team members. Those who did not find it particularly helpful explained that some of the principles were had to apply. It comes as no surprise, then, that students recommended more team assignments and more time with the communication instructors to develop their team skills.

Student Skill Development

Students complete two writing assignments and two speaking assignments. The first writing and speaking assignments are done individually and the second writing and speaking assignments are done collaboratively, for which students receive a team grade. The two individual assignments

focus on researching a contemporary civil engineering issue and preparing a paper and presentation about that issue. Scores for the individual presentation in Fall 2010 ranged from 70% to 100%, with mo = 80% and m = 77% and scores on the individual writing assignment ranged from 65% to 100%, with mo = 85% and m = 82%.

In addition to individual writing and speaking, students also complete a final project in teams about the Panama Canal. They have to write a report and prepare a team presentation. The scores on the team report in Fall 2010 ranged from 75% to 100%, with mo = 89% and m = 76%. The scores on the team presentation ranged from 86% to 100%, with mo = 93% and m = 91%. We were also able to track students' improvement in team presentation skills from rehearsal to in-class delivery. Specifically, students were required to meet with one communication instructor to rehearse their presentation before they gave it in class. The instructor completed the evaluation form just as she would if she were evaluating the final presentation. She assigned a grade and then led the students in a discussion of strengths and opportunities for improvement. The students then delivered their presentation in class a few days later. The other communication instructor attended the live sessions and evaluated the students' presentations. Presentation scores were recorded for both rehearsal (time 1) and in-class delivery (time 2). Results of a one-tailed t-test indicate statistically significant improvement from rehearsal to final presentation ($p = 0.0003$).

In short, average scores on students' speaking assignments improved from the first assignment to the second. We recognize that we are comparing individual and team scores; however, we are optimistic that the increase in averages, regardless of the comparison points to even marginal improvement in students' skill development. In terms of writing, we noticed an increase in the mode from 85% to 89%, but a decrease in the average score from 82% to 76%. We speculate that this decrease in average scores is the result of challenges inherent to collaborative writing, coupled with less in-class instruction and discussion of the assignment.

In addition to student skill development in writing and speaking, we also asked students to recall two specific things that they learned about writing and speaking in this class. The most commonly recalled aspects of the writing instruction are structure (introduction, body, conclusion, transitions), the importance of revision, and appropriate source citations. The most commonly recalled aspects of speaking instruction are the importance of practice/rehearsal, elements of effective delivery, and how to appropriately prepare PowerPoint slides.

Recommendations and Conclusions

Feedback from the students and discussions with the instructor team resulted in minor suggestions for improvement. We feel the writing instruction could be improved by adding a guided peer-review component. This would add a new dimension to writing instruction by having students act as critics. Peer feedback could be submitted via memo, thus introducing students to this professional genre. We also recommend enhancing the writing instruction by teaching students the importance of proper illustrations as supporting material. The addition of peer review and incorporation of visual communication should add depth to the writing instruction to challenge students and build on their high school knowledge base. In terms of oral communication, we recommend exposing students to the various approaches to slide design,

such as Presentation Zen or assertion-evidence. While we would not expect freshman students to develop a full presentation in this manner, we could present the information and encourage students to try out some of these techniques. Again, this will appeal to those students who have a basic knowledge of Power Point and challenge them to have more sophisticated slide shows.

In summary, increasing enrollment in civil engineering coupled with fixed, or in some cases, a decrease in instructional personnel challenge instructors to provide students with individualized attention and feedback. Yet, one-on-one contact is paramount to improving students' communication competence. To rise to this challenge, we offer a model of interdisciplinary team teaching that capitalizes on split sessions as the way to provide both introductory civil engineering information, while also consulting on speaking, writing, and teaming skills.

Bibliography

1. Accreditation Board for Engineering and Technology. www.abet.org.

2. Ford, J. D., & Riley, L. A. (2003). Integrating communication and engineering education: A look at curricula, courses, and support systems," *Journal of Engineering Education,* 92, 325-328.

3. Russell, J. S., & Stouffer, W. B. (2005). Survey of national civil engineering curriculum. *Journal of Professional Issues in Engineering Education and Practice, 131,* 118-128.

4. Sack, R., Bras, R. L., Daniel, D. E., & Hendrickson, C. (1999). Reinventing civil engineering education. *ASEE/IEEE Frontiers in Education Conference Proceedings,* session 13d3.

5. Jensen, J. N. (2003). A case study approach to engineering courses. *ASEE Conference Proceedings,* session 2653.

6. Schlosser, P., Parke, M., & Merrill, J. (2008). Decision-making in the design-build process among first year engineering students. *ASEE Conference Proceedings,* session 2182.

7. Linsky, E., Nemtzow, N., & Georigi, G. (2003). Teaching four different communication styles in freshman engineering. *ASEE Conference Proceedings,* session 1896.

8. Georgi, G., & Folan, L. M. (2001). Introductory design in freshman engineering. *ASEE Conference Proceedings,* session 2793.