Using Multi-Disciplinary Teams to Teach Communication to Engineers, Or "Practicing What We Preach"

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Abstract

Many new engineering courses tell students how important it is to write clear reports and proposals, deliver polished oral presentations, communicate effectively with clients, and work well on multi-disciplinary teams. This paper suggests one model for accomplishing these objectives: a design and communication course for engineering freshmen based on a cross-disciplinary approach and taught by multi-disciplinary teams. This paper will summarize the intellectual and practical similarities between design and communication that form the basis of our collaboration, explain how our cross-school course is administered and taught, discuss how we are evaluating student progress, and outline the benefits of teaching design and communication in this multi-disciplinary way. We argue that this team model strengthens the theoretical underpinnings of our course while improving learning outcomes in both communication and design.

Introduction

Over the past several years, as part of the new national focus on outcomes by engineering educators, industry mentors, and ABET evaluators, communication skills and teamwork have become a much more prominent part of the engineering curriculum.[1-2] It is the rare new course, particularly in engineering design or in introductory engineering courses, that doesn't strive to help students develop more of the communication competencies they will need in industry, that is, to communicate effectively with team members and clients, write clear reports and proposals, and deliver polished oral presentations. To help students acquire these skills, more and more engineering educators are exploring ways to integrate communication instruction throughout the engineering curriculum instead of sending students to stand-alone courses in English and speech, where the instruction has nothing to do with engineering and thus leaves the students responsible for learning how to apply their newly acquired knowledge to engineering.[3-8] In contrast, an integrated approach to communication instruction has the potential to show students that engineers value—and depend on—effective communication, just as team projects give students valuable experience in the teamwork skills they are likely to need in the workplace.

But integrating instruction in teamwork and communication into engineering courses isn't easy, especially when engineering faculty already have overcrowded syllabi and have little idea how to teach teamwork and communication—even if they are convinced of the importance of these topics. Moreover, teaching communication usually requires assigning and grading more papers, a burdensome task that many engineering faculty prefer to avoid.

At Northwestern, we have begun to address these problems by developing a two-quarter, project-based, core course for freshmen called Engineering Design and Communication. The course, which focuses equally on design and communication, has been collaboratively conceived, planned, and taught by a multi-disciplinary faculty from the College of Arts and Sciences Writing Program and several engineering disciplines. Each small section is team-taught by a faculty member from engineering and the writing program. To stress the point that communication is an integral part of engineering, all the communication requirements in this course—memos, progress reports, proposals, drawings, and PowerPoint presentations—stem from the work in design. When students complete two quarters of work, they get one credit in engineering and one in communication.

The multidisciplinary faculty collaboration—from engineering and communication—is crucial to the success of this course. Just as industry relies on multidisciplinary teams to bring together different skill sets and capacities to solve complex problems, so we have found that improving student communication benefits greatly from a variety of specialists working together. Engineering Design and Communication (EDC) takes advantage of this synergy. In addition, as we teach the course, we model the collaboration and teamwork skills we expect students to acquire. This is one of our strongest teaching tools: we practice what we preach.

Background: NU's freshman design course

Part of Northwestern's "Engineering First" program, EDC is a required course for all engineering freshmen, partially satisfying both their design requirement and their writing requirement. The goals of EDC are to:

- introduce freshman to the creative solving of complex problems
- nurture student's enthusiasm for engineering
- complement the more analytical courses that are part of the first-year curriculum
- improve students' abilities in written, oral, graphical, and interpersonal communication
- form a foundation for a new "culture of design" at the engineering school

EDC is a two-quarter course in which students attend one weekly lecture on design and two weekly sixteen-person sections. These are team-taught by faculty from engineering and writing. In first quarter of EDC, students are introduced to design and communication in a brief hands-on project; then, for the remainder of the quarter, four-person student teams design web sites for real clients that address real campus and community needs. These projects introduce students to the various stages of design. Students are coached in a user-centered approach to design, and learn a number of analytical tools and project management techniques. The projects culminate in three deliverables for clients and faculty: a prototype web site, a written report, and an oral presentation. Clients tend to be campus departments, research groups, and student organizations; EDC students have also designed web sites for local schools and small businesses.

In the second quarter of EDC, students apply what they've learned to new projects from a variety of disciplines. Again working for local clients and supervised by a pair of faculty from engineering and communication, teams tackle projects that span a range of problems and disciplines. Past EDC teams have developed designs like the following:

- an enhanced pager system for volunteer firemen
- a portable balance beam for disabled children
- an improved mobile CAD station for a local design firm
- an improved ergonomic rake handle (which may be patented by the students)
- several prosthetics for a local woman whose hand was injured in a fire, allowing her to play tennis, cross country ski, and write with a pen.

In both quarters of EDC, we make the problems faced by the student teams as open-ended as possible. We emphasize conceptual design rather than detail design: students are responsible for coming up with the best range of ideas they can, developing a good understanding of what the users' real needs are, and revising their concept until they strike a good bargain between the possible and the desirable. And at every stage of the process students must explain, clarify, and illustrate their ideas for real audiences: users, clients, peers, and instructors.

Teaching the process: design and communication

In EDC, we present design and communication as interconnected processes. Both require creativity, critical thinking, and effective decision making, and both are *iterative* processes. By requiring students to generate multiple design concepts and revise multiple drafts of their reports, we teach that revision is indispensable to both creative design and clear communication. Design prototypes and report drafts must both be subjected to scrutiny from multiple points of view; similarly, both designs and reports must be measured against user-defined requirements and criteria. The two-quarter structure of our course is also helpful here: because students go through the design process three times—in one introductory project and two major design projects—they are able to develop an increasingly sophisticated understanding of design and communication as processes that support and illuminate each other.

This awareness of process is important for several reasons. First, it helps students see that writing and speaking about a design are not things that happen after the design work is done. We present communication as a design tool: something that can be used to generate and develop ideas, not just write them up. Second, an awareness of process is essential when students work as teams. In order to draw on the creativity of all of its members, the team must cycle through the process of generating and evaluating different alternatives—both for the design project as a whole and for the specific assignments along the way. Finally, our focus on process helps students see the parallels between design and communication: designing for real users compares to writing for real audiences, and both are essential skills for a successful engineer. This is one of the most important insights we want students to take away from EDC—and one of the main reasons the engineering and communications faculty have come together to teach this course.

Using faculty teams to teach: the structure of EDC

EDC is able to integrate design and communication by relying on multi-disciplinary faculty teams in every facet of the course. EDC is planned by a core committee of 6-8 faculty drawn from both engineering and writing. They are responsible for handling the planning and administration of the course: designing the curriculum, recruiting and training faculty, planning and delivering the weekly lectures, scheduling sections, lining up clients, etc. The committee meets weekly, and has developed a close working relationship over the past four years.

Communication and engineering faculty also take a collaborative approach to planning and delivering the lectures. The winter quarter lectures are delivered in pairs, with both communication and engineering faculty taking an active role. While the topic of each week's lecture may stress design over communication, or vice versa, the other component's voice is always present. Moreover, most lectures include an interactive component led by a faculty member other than the primary teaching pair. Thus students can see how our faculty team relies on team members' different strengths—one person may be proficient in solid modeling, while others may have experience in web site design, conducting interviews, or other areas.

Another structural element that fosters integration of design and communication is the weekly faculty "cluster" meetings, where groups of faculty compare notes, ask questions, and prepare for the upcoming sections. In addition to making a large and complex course run more smoothly, cluster meetings remind the faculty of EDC's dual nature and purpose. Even more important, the cluster meetings give us a chance to engage in the same kind of collaborative learning that we encourage students to do in their teams. Thus we expand our own knowledge, working as a group and grounding our understanding of design and communication in these social interactions. [9]

Students get their closest view of faculty teams working together in small group sections. Each section is taught by a pair of faculty who use coaching as the primary pedagogical approach and who bear equal responsibility not only for coaching the students, but also for responding to their work, and assigning grades. Both faculty members comment on the efficacy of designs, the content and clarity of scripts for user interviews, and the organization and clarity of draft reports. Both instructors show students how to brainstorm, sketch, and use matrices for decision-making. Both instructors give written comments on the report drafts as well as final reports. Both instructors comment on the quality of student design reviews and final oral presentations. While each faculty member brings his/her particular expertise to the course, the process of coaching the students on their projects is collaborative and interactive.

While this sharing of responsibility may seem to double each instructor's burden, we have found that in fact it adds to the pleasure of teaching the course. Like the cluster meetings, our collaborative teaching expands our knowledge of both design and communication and teaches us more about how the two processes support each other. These are lessons we pass on to our students.

We have also found that students benefit from getting responses from different instructors. By having to account for two sets of criticism, students come to understand that reports and presentations have multiple readers with differing perspectives. Writers need to take all these perspectives into account. In addition, because each instructor responds to both design and communication issues, students also come to understand that communicating their ideas clearly is part of design, not posterior or subordinate to it. Good design requires clear communication, and good communication creates better designs.

Evaluating the course

Based on our experience in EDC—and how our course design bears out ideas in the engineering literature—we assume that our freshmen benefit from a number of key elements in the course: the synergy between communication and engineering faculty, the opportunity to work with faculty from a variety of engineering disciplines, and the exposure to a range of communication styles and examples of teams in action. For example, the literature suggests that one way to improve learning for women and minorities in engineering instruction is to provide more varied teaching and thinking styles.[10-12] Our cross-disciplinary collaboration accomplishes this because in any one quarter of EDC, we bring together engineering faculty from different fields and specialties. And because the communication faculty includes more women than men, the gender ratio of our faculty is closer than usual to that of the students we are teaching.

But does our cross-disciplinary, team-teaching approach have a direct bearing on student success, one that justifies its expense in person hours? In the fourth year of the program—and the first in which EDC is required for all entering freshmen—we are beginning to measure that aspect of the course in a systematic way. The information we have gathered so far from student surveys, faculty interviews, and client responses shows that students learn a great deal about both design and communication in EDC, and that they understand the connections between the two.

Student surveys. Students were asked to complete a survey at the end of EDC, one section of which dealt with how much they had learned in different aspects of the course (Table 1). Students were asked to rate answers from 1 (“learned little) to 5 (“learned a tremendous amount”), using N for “no opinion” or “no opportunity to tell.”

Table 1. Student Learning in EDC, Spring 1999 (Data prepared by Janelle Wendorf)

Key areas of learning	Total N	Total 1	Total 2	Total 3	Total 4	Total 5	Total numeric answers	%1&2	%4&5
Working in teams	0	0	3	14	57	121	195	2%	91%
Engineering design process	0	0	4	16	77	100	197	2%	90%
Managing projects	2	0	4	22	69	97	192	2%	86%
Role of communication in design	0	3	4	23	77	87	194	4%	85%
Communicating with supervisor and client	0	0	8	31	79	76	194	4%	80%
Role of creativity in engineering	0	2	9	31	79	75	196	6%	79%
Writing reports/ proposals	1	2	13	29	70	81	195	8%	77%
Giving oral presentations	0	3	11	43	79	59	195	7%	71%
Holding design reviews	0	4	4	58	79	50	195	4%	66%
Conducting meetings	1	6	21	43	68	57	195	14%	64%
Doing research (such as reverse engg., interviews, web research, library research)	1	6	16	52	61	61	196	11%	62%
Engineering fields/disciplines	2	12	38	63	53	29	195	26%	42%
Writing interview guides	4	16	36	63	57	20	192	27%	40%

As these answers indicate, most students believe they learned a tremendous amount in EDC about design, communication, and teamwork. The student responses about communication are particularly interesting to us. While most students said they learned a lot about writing reports and making presentations, an even higher percentage said that they learned a lot about the role of communication in design. This may mean that even when students have doubts about their own performance in writing and speaking, they still see the connections between the parts of the course.

Another measure of the EDC's success in combining teamwork and communication with engineering design is a comparison between those who have taken it and those who haven't. Northwestern's Office of Undergraduate Engineering administered a survey to sophomore and junior engineering students and asked them to rate their abilities in different areas A striking difference emerged in the question of working in teams, where the students who had taken EDC rated themselves significantly higher than those who had not.[13]

Faculty surveys. All of the faculty who teach EDC comment on the tremendous amount they have learned from collaborating with faculty from the other school, and all find the course to be an exciting, albeit challenging, teaching experience. A number of engineering faculty who taught in the course during 1998-99 were interviewed to determine what elements of the course they considered most important, and how these elements could be taught better. (The communications faculty were not formally interviewed, but also report that they are satisfied with the course's direction.) All the faculty rated the core design and communication concepts as

"must teach" elements of the course. However, based upon faculty feedback, we have been redesigning the way we teach certain concepts, such as brainstorming and design reviews.

Conclusion

Borrowing a model from industry, we have found that teaching engineers in multi-disciplinary teams has several benefits. First, it strengthens the theoretical underpinnings of an engineering course that claims to emphasize communication . The links in our course between design and communication are emphasized by the fact that there are always two perspectives present when the course is planned, taught, and improved. Second, integrating design and communication so thoroughly improves students' learning in both areas.

Finally, our cross-disciplinary collaboration provides both an occasion and an incentive to keep exploring what we have in common, and what differences we must negotiate. The result has been an almost continuous process of planning, assessment, and revision as we strive to keep the two parts of our course in balance and in synch. In doing so, we have applied to our own process of course design something of the same team-based, user-driven, audience-conscious process that we teach our student: practicing what we preach leads to a high quality course.

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