AC 2007-827: ASSESSING THE INTEGRATION OF COMMUNICATION INTO ENGINEERING CURRICULA

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Assessing the Integration of Communication into Engineering Curricula

Introduction

In a previous paper, we explored the requirements for engineers to be effective communicators and how such requirements could be integrated into engineering curricula.[1] Prominent among the cited requirements was the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) outcomes-based accreditation initiative *Engineering Criteria 2000*[2] Criterion 3 under "Program Outcomes and Assessment" which emphasized the necessity for engineering graduates to demonstrate the ability to communicate effectively. We also pointed out other sources specifically citing the importance of effective communication in the current and evolving engineering environment.

Our 2006 paper further explored a concept for integrating communication requirements into the engineering curricula at Louisiana State University (LSU). Although the approach described had some apparently unique aspects, another paper presented at this same conference revealed an interesting trend in the teaching of communication-related topics in engineering courses[3]. The authors of this paper reported data from surveys, conducted in 1994 and 2005, that queried ABET-accredited engineering programs regarding the topics taught in their engineering capstone design courses. This paper revealed a significant rise in the teaching of communications-related topics between 1994 and 2005.

Integration of communication into the engineering curricula at our university was previously described in our 2006 paper. This current paper will review these initiatives that are underway and report on their current status. More importantly for this paper, we will discuss various tools that have been developed to assess the effectiveness of the communication integration initiative. Preliminary data from these assessment tools will also be reported.

Current Status of Communication Initiatives in Engineering

Several initiatives have been made possible through cooperative efforts with a campus-wide Communication across the Curriculum (CxC) program. The CxC program was established in 2003 through the generosity of a now-deceased engineering alumnus who wished to establish a university-wide program that would focus on improving students' communication skills. Because he was an engineer, his primary interest was to accomplish this task in engineering classes first, but from the beginning, he envisioned this program as a means of addressing student needs across all curricula. The initiatives described below are among the key elements of the CxC program that have been successfully implemented in the College of Engineering (COE).

Summer Faculty Institutes. The first step in integrating specific communication skills into the COE was to identify a core faculty group representing each of the departments. This core group of eleven faculty members prepared for a leadership role in the communication project by attending a CxC-sponsored Faculty Institute during the summer of 2005. The engineering team received a comprehensive orientation to the campus-wide CxC program and explored how their participation could lead to the incorporation of communication goals in the COE curriculum. They worked on their individual syllabi, as well as college-wide plans for a COE

Communication Studio. They shared their ideas about an engineering graduate's need for communication skills and their newly-revised syllabi with faculty members representing all colleges, who provided an interdisciplinary audience for their perspectives.

The follow-on CxC 2006 Faculty Institute had 33 faculty participants, with engineering faculty making up the majority. The focus of the 2006 Summer Institute was on assessment strategies in the four communications flavors: oral, written, visual, and technological. Not only did participants explore assessment strategies and rubric design, they also learned ways to effectively integrate iterative assessment throughout the course of a project and a semester. Drawing upon 2005 faculty participants set the tone for the 2006 Summer Institute by discussing the successes and setbacks they experienced in their classrooms when implementing communication strategies. Outside consultants from other universities again led workshops on how to assess oral, written, and visual communication projects.

The outcomes resulting from these two faculty institutes will be further discussed as part of our assessment later in this paper.

Engineering Communication Studio. A major accomplishment during the fall of 2005 was the opening of the first of several planned Communication Studios on campus. These studios are intended to be integrated into various university colleges and built around a theme that is critical to that specific college. In engineering, the central theme is facilitating group communication dynamics, such as are central to a design team.

The Engineering Communication Studio (Studio) has state-of-the-art technology applications at 17 computer work stations and comfortable lounge seating for an Internet café atmosphere, shown in Figure 1. The lounge area is located in a wireless Internet hotspot, making it a popular location for students using personal laptop or notebook computers. With its movable seating, this area is also heavily used for small group discussions of team projects.

Figure 1: Group Discussions in the Informal Lounge

A conference room (Figure 2) in the Studio is equipped for critiques of oral presentations, one of the requirements of many Communication-Intensive courses. Most useful is a SMART Board™, a touch-sensitive display permitting control of computer applications directly from the display,

including writing notes in digital ink that can be saved or shared via email. The conference room is further equipped with a conference telephone, a large dry erase board, and modular furniture, making it a functional site for capstone design teams to conduct brainstorming sessions, have design reviews, and discuss progress and details with their advisors and corporate sponsors.

Figure 2: Capstone Design Team Using Conference Room and SMART Board™

In three group-work areas, wall-mounted dry erase board cabinets facilitate the generative, informal aspects of the creative process. In addition to these cabinets, three portable dry erase easels, shown in Figure 3, are available for groups to move throughout the informal lounge.

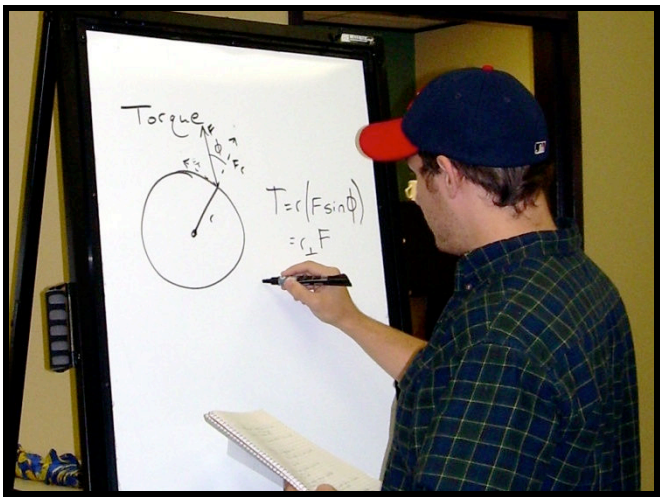

Figure 3: Problem Solving Using a Dry Erase Easel

The Studio's three-dimensional (3-D) printer (Figure 4) enables students to see their designs come to life by creating a functional ABS plastic model directly from design files. This allows students not only to construct complex shapes, but also to test the form, fit, and function of individual components in their overall design project. One positive outcome of locating the 3-D printer in a setting shared by all the engineering disciplines has been the growth of applications faculty and students can now envision for this resource.

Figure 4: Three-Dimensional Printer

A large-format printer (Figure 5) allows students to create posters and CAD drawings in formats up to 42 inches wide. The Studio offers bond and photographic quality paper options, which allows LSU students, faculty, and staff to create poster drafts in grayscale before printing in color on glossy paper.

Figure 5: Large-Format Printer

In order to aid in the development of digital portfolios and other communication projects, the Studio offers resources for student checkout. Students can choose between a corded and a wireless microphone system, which works with either a lapel microphone or a handheld, omni-directional microphone. This microphone system is compatible with the digital camcorder and tripod that are also available for student use.

Two highly portable projectors and projection screens are available for giving out-of-Studio presentations at remote locations such as laboratories and field-research sites. Students can check out an eight megapixel digital camera that is ideal for capturing images both for electronic applications, such as presentation slides and websites, and large-format print applications, such as posters and CAD drawings. In addition to audio-visual equipment checkouts, the Studio

features a growing reference library, including engineering-specific references and composition stylebooks.

To further support students and faculty, the Studio is staffed with a Communication Coordinator and two Communication Instructors. These three professionals work directly with students and faculty to enhance students' written, oral, visual, and technological communication skills. The support for faculty ranges from assisting in the development of course syllabi that integrate communication components to developing rubrics for assessing critical skills and providing classroom instruction on communication-specific topics. This cooperative relationship often leads to faculty referring students to the Studio instructors for individualized and team tutorials. It is not lost on the students that the instructors are familiar with the course content and goals; therefore, students perceive the tutorials as being more relevant and having a more immediate impact upon their academic performance than stand-alone courses or tutorial programs outside the COE. One goal of CxC is to facilitate more on-site tutoring from other programs so that their assistance will also be perceived as more relevant to engineering students.

Tools to Measure Effectiveness of Communication Initiatives

As the concepts for the communication initiatives evolved, so did the development of tools to assess the effectiveness of these initiatives. The assessment tools discussed below and the preliminary results discussed later in this paper are still evolving as we incorporate better integration methods in the curricula.

Engineering Communication Advisory Council. An Engineering Communication Advisory Council (Council) was formed to provide an independent review of ongoing initiatives to improve graduating engineers' communications skills. The Council is a non-compensated group of senior-level engineers, appointed to rotating three-year terms by the Dean of the College of Engineering. The Council is a small group of engineers who hold senior-level positions in government and private industry. These engineers typically communicate at varying technical and managerial levels, conduct comprehensive evaluation of engineers' work products, and set the criteria for the education and skills desired in new hires in their respective organizations. One important attribute of Council members is anticipated stability in the local geographical area, thus ensuring at least three years of continuity as members. This continuity is required to help gauge the long-term progress of the communication initiatives in the COE.

The Council convenes formally as a group on a semi-annual basis at the LSU COE. The initial meeting emphasized the communication initiatives within the College and examples of the communication-intensive projects produced by sophomore and capstone design classes. Between scheduled meetings, additional interactions have occurred between Council members and the COE. Examples of these interactions are reviews of examples of students' written reports, and occasional attendance at scheduled oral presentations by students. One mechanism for enhancing this review process is the use of students' Digital Portfolios that have been developed under the guidance of the CxC Program. Agenda items for scheduled meetings are coordinated by the COE and the Council prior to each meeting.

Given the Council members' senior positions in their organizations, they bring a unique assessment of what communications skills are needed by their new hires for future success in their organizations, and whether LSU graduates meet their perceived criteria.

Communication-Intensive (C-I) Courses. Students take courses that focus on any two of CxC's four communication emphases—written, oral, visual, and technological. For example, senior design courses require students to produce written reports and deliver oral presentations. Faculty members teaching these courses give students direct feedback on assignments, which the students then have an opportunity to revise. These courses also emphasize the informal, generative portions of the creative process, such as brainstorming and prewriting in design notebooks. In order to prepare faculty to address communication assignments in their classes effectively, CxC offers workshops throughout the year, as well as the Summer Institute, featuring experts in a variety of communication based fields.

High-Level Communicators (HLC). The High-Level Communicator certification recognizes students who meet the highest standards in written, oral, visual, and technological communication by receiving a special designation on their university transcripts. HLC students must demonstrate communication skills by being leaders on and off campus, maintaining a 3.5 GPA in C-I courses, and demonstrating excellence in all four of CxC's areas of emphasis by creating digital portfolios. Many of these students are eligible to serve as communication mentors, giving peer review and feedback to students seeking help with communication-based activities in the CxC studios.

Digital Portfolios (d-portfolios). The purpose of digital portfolios is two-fold. First, the digital portfolio provides a best-works showcase for students to present their most successful communication projects to potential employers or graduate school admissions committees. Students complete these projects through a variety of rhetorical strategies and the latest web technologies, such as Macromedia Dreamweaver and Macromedia Flash. Students seeking High-Level Communicator designation must present examples of written, oral, visual, and technological communication in their digital portfolios. Second, the digital portfolio provides a forum for students and faculty to assess student progress through specific assignments and deliberation upon the students' entire college learning experience. Students must include written reflections on their experiences in building the portfolio and on their experiences in completing communication assignments. CxC requires these reflections for assessment purposes only, and does not require them to be made public; however, the students may include these reflections in the public portion of their portfolio if they wish to do so. Ideally, students will work on their portfolios throughout their college experiences so that the result is a cumulative four-year project that serves as a means for reflection and assessment, as well as a supplement to resumes for prospective employers or applications for graduate programs. The first d-portfolios and support services were piloted in 2005 with nearly a dozen participants. As of January 9, 2007, one hundred seventy-one (171) LSU students were building digital portfolios; forty-one (41) of those students were from the College of Engineering.

Tracking Studio Usage Patterns. At the beginning of the Fall 2006 semester, the Engineering Communication Studio implemented a system to track student profiles and Studio usage patterns. We selected the software package AccuTrack, developed and distributed by Engineerica Systems, Inc., because of its versatility for our applications. AccuTrack is database software specially developed for academic centers and learning labs. AccuTrack is comprehensive software with many uses such as tracking students' visits, tracking usage of services, managing tutorial appointments, tracking loaned materials, and collecting feedback on services. Students entering the Studio log onto the AccuTrack computer using either their unique student

identification code or swipe their ID card through a reader. On their first visit, students are queried about selected demographics, such as academic major and classification. On subsequent visits, they simply select the service that they intend to use. Upon exiting the Studio, students log out of the system. AccuTrack is also used to manage appointments with Studio staff and to track the usage of loaned equipment.

Assessment of Preliminary Results

The inaugural implementation of communication initiatives at our university was disrupted in the fall of 2005 by natural disasters, thereby making our data covering three semesters (Fall 2005, Spring 2006, and Fall 2006) somewhat misleading. In reality, our assessments are more representative of the latter two semesters of our initiatives. It should also be noted that the assessment process has evolved as our experience with our initiatives has grown. That is not to say that we've created a "moving target" without an acknowledged baseline. We're merely conceding that we're learning where we need to put emphasis, and then to assess whether measurable progress is being made. The results discussed below are preliminary, but they've proven valuable in setting directions for our program.

Advisory Council Feedback. Our first council meeting focused on demonstrating to the members how the COE is implementing its communication initiatives, and then soliciting feedback as to the members' general impressions. These senior engineers provided positive feedback on the COE's efforts, but also voiced a concern that the students may not be getting a full appreciation for the importance of communication skills to the practicing engineer. Building upon this latter comment, the council members agreed to participate in a panel discussion with students and council members in the Spring 2006 semester. This well-attended panel discussion had as its theme, "What skills or traits is my company looking for in a young engineer and what will the newly hired engineer experience at my company." Among the companies represented were Shell Oil, BASF, Motiva, and Ratheon Missile Systems. Student participation in this open discussion resulted in numerous comments regarding students' appreciation of the importance of communications to their future.

At a Fall 2005 Council meeting, members were given more detailed information on the capstone design process, including a presentation by one multi-discipline design team. Council members offered several valuable suggestions that could improve the communication integration process. Of particular note from this meeting, were the members' positive responses to the d-portfolio concept. Their comments centered upon the value of this to demonstrate the breadth of communications skills as well as their technical cognizance.

Communication-Intensive (C-I) Courses. Engineering courses receiving the C-I certification have grown steadily each semester to reach a total of 18 courses having been certified. More significantly, each of the engineering disciplines is represented in this listing, with capstone design courses all included. Two of the disciplines have also had sophomore level course C-I certified, demonstrating a growing recognition of the importance of developing communication skills earlier in students' academic experience. A questionnaire was used to assess students' opinions regarding the value of C-I courses. A total of 60% of those completing the C-I course evaluation form indicated that the course was highly effective in improving their individual

communication skills. Additionally, 68% indicated that they would seek more C-I courses to improve their communication skills.

High-Level Communicators (HLC). Students who have entered the HLC program number 171 across the entire campus. Of that total, 41 students are engineering majors, with each of the engineering disciplines represented. It is significant to note that although 24% of the HLC applicants are engineering majors, the COE only represents 12.2% of the entire undergraduate population. We believe that this demonstrates that engineering students are becoming more aware of the value of communication skills in their professional futures, and are willing to put forth the additional effort required to have the HLC designation on their transcripts.

Digital Portfolios (d-portfolios). Figure 6 shows an example of one of the first d-portfolios developed by a mechanical engineering student. Since this was early in the program implementation, it focused primarily on the student's current skills and accomplishments, and became an important element in her career development. Figure 7 is an example of a more recent d-portfolio developed by an electrical engineering student. This example shows more of the student's academic development during her undergraduate program. Figure 8 is another electrical engineering student example, with this student also highlighting communication skills outside the traditional academic environment.

As of this date, there are a total of 41 engineering students with d-portfolios in various stages of development. With the growth of these d-portfolios, our preliminary assessment is that we are seeing better quality, probably owing to both the student and staff experiences gained. As the d-portfolios are fleshed out with more examples of students' communication examples, we will be better able to assess student growth in the communications skills.

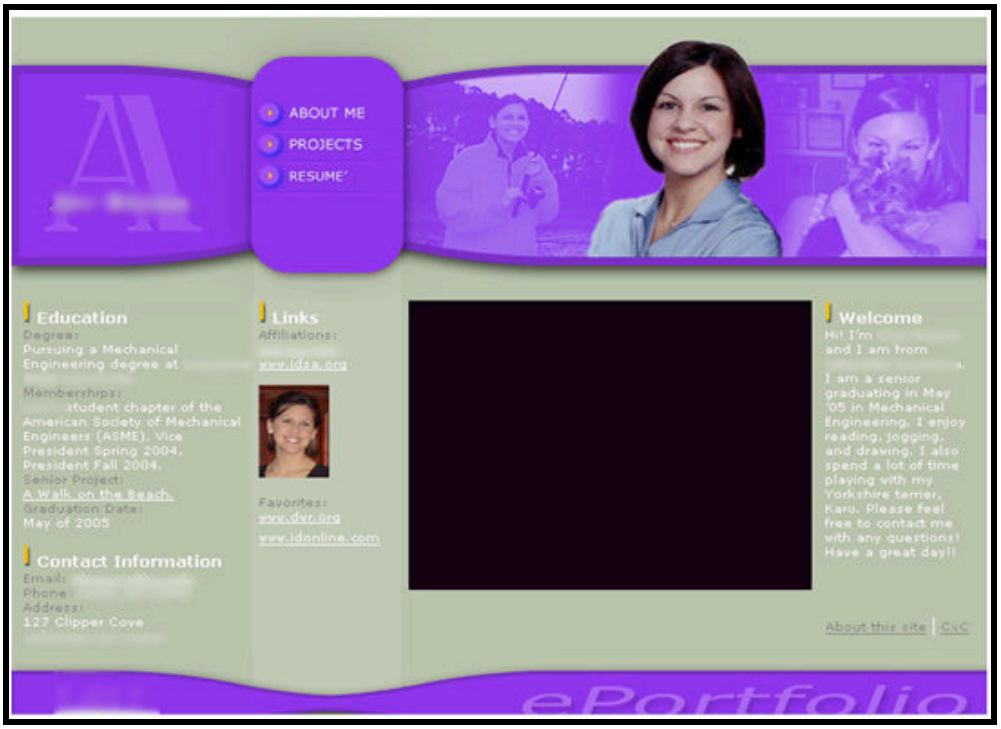

Figure 6: Example #1 Engineering Student d- Portfolio

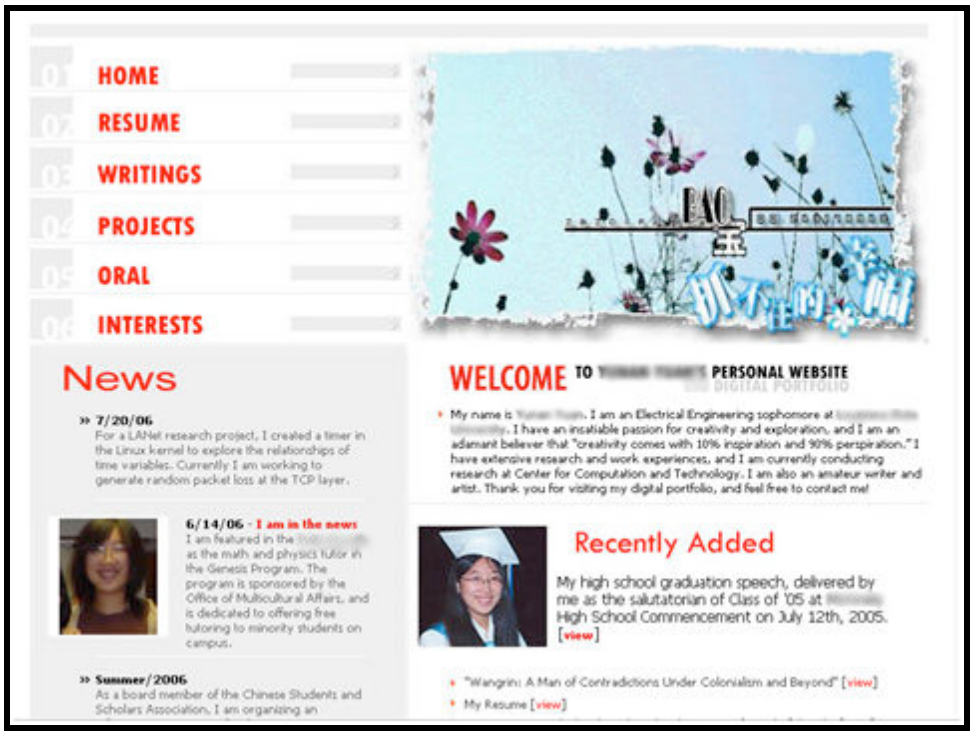

Figure 7: Example #2 Engineering Student d-Portfolio

Figure 8: Example #3 Engineering Student d-Portfolio

Studio Usage and Student Profiles. Tracking profiles for student utilization of the Engineering Communication Studio began formally during the Fall 2005 semester. Table 1 shows the overall profile of students who used the Studio during the semester, and as expected, engineering majors

represented the bulk (71%) of the users. Interestingly, engineering students returned for more visits (78.8% of actual sign ins to the Studio), and represented an even greater proportion of time (81%) in the Studio. That the Business College was the second most represented college is not surprising because it is co-located with the COE in the Center for Engineering and Business Administration Building. These data indicate that the Studio is reaching its target audience, i.e., undergraduate engineers with emphasis on upper class (Junior and Senior classifications)

Table 1. Profile of Student Visitors, Fall Semester 2006

Major College	# Visitors[1]	%	# Sign Ins[2]	%	Time of Use[3]	%
Agriculture	8	1.0	19	0.4	43.17	0.5
Arts & Sciences	17	2.2	30	0.6	59.59	0.8
Basic Sciences	14	1.8	29	0.6	41.35	0.5
Business	168	22.0	813	17.5	1208	15.2
Education	4	0.5	6	.0.1	11.40	0.1
Engineering	542	71.0	3654	78.8	6445	81.0
Graduate School	10	1.3	88	1.9	146	1.8
Degree						
B.S.	703	92.1	4298	92.6	7430	93.4
M.S.	49	6.4	319	6.9	479	6.0
Ph.D.	11	1.4	22	0.5	46.28	0.6
Classification						
Freshman	43	5.6	116	2.5	270	3.4
Sophomore	115	15.1	783	16.9	1362	17.1
Junior	170	22.3	1444	31.1	2651	33.3
Senior	376	49.3	1959	42.2	3178	39.9
Grad. Student	59	7.7	337	7.0	490	0.2
Semester Totals	763	100	4639	100	7955	100

Notes:
1. # Visitors represents students who have visited studio at least one time
2. # Sign Ins represents number of times that students have visited studio
3. Time of use represents number of hours students were signed into studio

Summary and Conclusions

We believe that we have initiated a program that is effectively integrating communication skills into the engineering curriculum at our university. Our preliminary assessment tools have yielded encouraging feedback on these initiatives, but more importantly, they have enabled us to fine-tune our program direction to better meet our student and faculty requirments.

We must acknowledge that the number of C-I courses in the COE remains a small percentage of the total number in the curriculum. The faculty members who have attended the CxC-sponsored Faculty Institutes have become reliable proponents of the program objectives, but they are still a

small minority of the total number of engineering faculty. In lieu of dramatically increasing faculty attendance at future Faculty Institutes, we are challenged with finding alternative means to familiarize more faculty with the value of communication skills and the resources available to assist them with integration of these skills into appropriate courses.

Most of our current successes have been with upper level courses, particularly capstone design courses. We believe that a key to continued future success is to certify more lower level engineering courses as C-I. This will help build a culture and expectation within both the students and faculty that communication skills are fundamental elements in the array of requirements of each engineering discipline.

References

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