



Development and Assessment of an Innovative Program to Integrate Communication Skills into Engineering Curricula

Dr. Warren N. Waggenspack Jr., Louisiana State University

Dr. Warren N. Waggenspack, Jr. is currently the associate dean for Academic Programs in the College of Engineering and holder of the Ned Adler Professorship in Mechanical Engineering at Louisiana State University. He obtained both his baccalaureate and master's degrees from LSU ME and his doctorate from Purdue University's School of Mechanical Engineering. He has been actively engaged in teaching, research and curricula development since joining the LSU faculty in 1988. As associate dean, he has acquired funding from NSF to support the development of several initiatives aimed at improving student retention and graduation rates as well as supporting faculty with development with effective learning and teaching pedagogies.

Prof. Sarah Liggett, Louisiana State University

Mr. Warren R Hull Sr. P.E., Louisiana State University

Warren R. Hull, Sr. is the Engineering Communication Studio Manager at Louisiana State University. He earned a B.S. from Louisiana State University and an M.S. from Harvard University. He is a licensed professional engineer whose engineering career spans over 40 years. Prior to joining LSU, Hull was a senior partner with an international engineering firm. He was also a career U.S. Air Force officer, retiring in the rank of Colonel.

Mr. David Bowles, Louisiana State University

David "Boz" Bowles is a technical communication instructor in the Engineering Communication Studio at Louisiana State University. He earned a baccalaureate degree in English and a Master of Fine Arts in Creative Writing from Virginia Commonwealth University.

Paige Davis, Louisiana State University

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Abstract

In 2005, a pilot for a campus-wide program, Communication across the Curriculum (CxC), was initiated in the College of Engineering with the goal of integrating communication requirements into various undergraduate curricula at Louisiana State University. A core element of this program was the designation of courses as Communication Intensive (C-I) provided they satisfied several communication-specific criteria. Foremost among the criteria were the use of informal communication to enhance learning and formal, discipline-specific communications to publicly share ideas, the use of a draft-feedback-revision loop, and a requirement that at least 40% of the course grade be based on communication-specific assignments.

Recognizing that these criteria could be challenging to implement, especially in capstone and laboratory courses, program administrators developed periodic discipline-specific workshops, an annual Faculty Summer Institute, and a professionally staffed, discipline-specific communication studio to aid faculty development and student instruction. These resources and how they evolved are illustrated using sample innovative communication assignments. Faculty commitment has grown to the point that all engineering disciplines have certified C-I courses or labs as a part of their capstone experiences. Many disciplines have at least two and some as many as the four required courses designated C-I.

Student interest was enhanced by establishing criteria for attaining a Distinguished Communicator certification to be awarded at graduation and noted on the students' transcripts. Since many of the introductory engineering courses have been designated as C-I, students soon appreciate the importance of communication skills in their academic work and professional futures. They also become aware of the opportunity for achieving the Distinguished Communicator certification. With successful integration of CxC throughout the engineering curricula, it is no coincidence that engineering students are disproportionately represented among the Distinguished Communicators in all the disciplines on campus.

Multiple methods have been instituted to assess the success of this program:

- An Engineering Communication Advisory Council to semi-annually review the program objectives and provide recommendations for enhancements
- An analysis comparing the required resource investment against the historical reliance upon a technical writing course to develop engineering students' communication skills
- A survey of faculty showing that student learning of technical content is enhanced by teaching strategies used in C-I courses
- Periodic survey of students in C-I courses in which responses were overwhelmingly positive

These assessments, as well as their implications for the future development of the program, are examined and discussed in detail.

Introduction

Ensuring that students learn the requisite fundamentals of engineering and its mathematical and scientific underpinnings is a daunting challenge; however, students benefit from the incorporation of other skills and a deeper understanding of the professional environment into the full curriculum. Such benefits spurred the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) to develop an outcomes-based accreditation initiative called Engineering Criteria 2000¹ (EC2000). One of the EC 2000 criteria (Criterion 3 under “Program Outcomes and Assessment”) is the necessity for engineering graduates to demonstrate the ability to communicate effectively.

While considered progressive and innovative, EC2000 was not without its critics. Funded by a National Science Foundation grant, the American Society of Mechanical Engineers (ASME) completed a one-year study of EC2000² that revealed some difficulties with its implementation. One finding of this study warrants particular discussion here. The contribution of an external Advisory Board was described as follows:

“Involvement of the program Advisory Board was expressed as a positive result of EC2000. These groups provided a very useful resource to the program in establishing educational objectives and defining associated measurements of student outcomes. The major design experience benefited from board input, particularly with regard to ‘real world’ problems and improvement in communication skills.”

Communication across the Curriculum (CxC) is a program that was established at our university in 2005 to integrate communication skills into the technical course content. It has been well received by both students and faculty and has evolved using innovative techniques. Success in meeting the EC2000 Criterion 3 outcome and answering the ASME identified concerns have been well documented in previous publications that will be reviewed herein.

More recently, the National Academy of Engineering *Educating the Engineer of 2020*, *Adapting Engineering Education to the New Century*³ and the American Society of Civil Engineers’ *The Vision for Civil Engineering in 2025*⁴ have both mentioned the need to better prepare engineers to operate on the global stage. In addition to these publications, our own advisory council cited the need for our graduates to improve their cultural awareness and to improve their understanding of the global business environment. Many of the lessons learned by integrating communication skills have been adapted to address this additional critical need.

In 2003, an alumnus gave a major gift to Louisiana State University (LSU) to establish a program that would improve students’ communication skills. Because he was an engineer, he was especially interested in enhancing the abilities of engineering students, but from the beginning, the vision for the program was that it would be university-wide. Early on in the planning stage, it was decided that communication skills would be recognized in four modes: written, spoken, visual, and technological. These skills would be integrated into designated courses, resources would be made available to support both students and faculty in these courses, and an incentive system would be established to encourage students to go beyond these courses

to further hone their communication skills. These critical components and many of the innovations resulting from them are discussed below.

Communication Intensive (C-I) Courses.

Courses that focus on any two of the four communication modes (written, oral, visual, and technological) can be certified as Communication-Intensive (C-I) courses. Faculty can review C-I course requirements on a university website and then submit documentation via that website to receive the C-I designation. The requirements for C-I certification are

- Use of informal communication for learning and formal communication for sharing ideas publicly
- Emphases on at least 2 of 4 modes
- Student/faculty ratio of no greater than 35:1
- Focus on genres and audiences appropriate to the discipline or profession
- Dedication to effective communication techniques
- Use of draft-feedback-revision process
- 40% of course grade based on communication work
- Ethical and professional standards for all class work

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 a 2008 paper, we showed examples of engineering assignments utilizing the feedback and revision loop and informal writing.⁵ In another paper, we explored some innovative assignments that help develop students' visual communication skills.⁶ Of these C-I course certification requirements, the requirement that 40% of course grade be based on communication work seemed to meet the most resistance from faculty. A faculty survey we reported in 2009 and discuss later in this paper demonstrates how many of the reservations about this requirement were allayed.⁷

Feedback and Revision Techniques. One of the challenging requirements of C-I courses in engineering is that students must receive feedback from the instructor on drafts of formal assignments. Several strategies have been adopted by faculty to accomplish this requirement. Some classes require that the formal papers be broken into smaller assignments. In some cases, these are separated into several components. For example, in one senior lab, preliminary lab reports are collected and graded as stand-alone assignments, but the instructor's comments are designed to aid in the composition of the final lab report.

Another approach is to break a large assignment into smaller components following a typical composition process. Students might turn in a topic proposal, followed by a preliminary outline, then an annotated bibliography, and then a series of drafts which are revised and edited into their final form. One instructor uses PowerPoint™ presentations as a storyboarding method, which leads students into their preliminary outlines, and finally into the drafting process. In other classes, the revision process is determined by the student rather than the instructor. For example, in one senior lab, students turn in a variety of lab reports for grading. However, they are required to choose one of these graded reports for revision and resubmission for a higher grade.

Examples of Informal Writing Techniques. In one engineering capstone course, students are required to keep an informal design notebook. Students are encouraged to use the notebooks as a means of documenting their progress through the design process. This notebook is collected, and a portion of the notebook is graded. The professor reads 35 entries marked by the student as “quality entries.” These entries are graded on the perceived usefulness to the individual student and the design group rather than a strict set of formal requirements. The graded portion of these notebooks is a relatively minor part of the notebook as a whole. Non-graded entries are risk-free informal writing in which the student reflects on aspects of the design process as well as the composition of oral presentations and bi-weekly reports. The notebook’s value is intended to be as a form of prewriting. Students beginning the process of writing a formal report find that they have already written extensively on every aspect of their project.

A different example of informal writing is evident in another Engineering department’s capstone course in the form of periodic project updates in oral presentations. Student groups are required to show how their planned or completed tasks will meet the objectives of their senior projects. Laying out multiple tasks, complete with Gantt Charts, creates a storyboard environment in which the students informally write and revise their design projects.

Senior Design Team Posters. One example of a visual communication assignment is the use of technical posters created by Petroleum Engineering design teams to demonstrate their project backgrounds, technical proposals, and final results. While common in research forums, posters are only now emerging as an appropriate communication medium in the undergraduate curriculum. The projects are designed and executed by teams of 3-4 students, usually with both an industry mentor and a faculty advisor. The posters are prepared and exhibited at the end of the second semester, when the projects are near completion.

With its large-format printer and array of digital cameras and associated equipment, the Engineering Communication Studio (a resource that we will discuss in more detail later) is well suited to support this undergraduate project. Studio staff and undergraduate mentors provide the teams with guidance in poster layout and the mechanics of preparation. This guidance takes a variety of forms, including in-class presentations on poster composition by Studio staff, consultation with individual students and student teams, and faculty feedback on poster drafts. Because of the C-I course requirement that faculty give feedback on drafts of major projects so that students have opportunities for effective revisions, students in C-I courses receive clear guidance on grading criteria for each specific assignment, as well as an improved understanding of conventions of visual communication in technical fields.

The posters provide an opportunity for the students to illustrate and document both the background information of their projects (geologic setting, drawings and schematics of equipment, photographs of field situations), and the data derived from executing the projects (graphs, well logs, maps, 3-D diagrams). Conclusions and recommendations are also included on the posters.

The posters are evaluated by the LSU Petroleum Engineering Department’s Industry Advisory Group, composed of a cross section of executives from the upstream oil and gas industry. A

poster session is held with the teams in attendance, and the members of the advisory group visit with each team to discuss the project results. The teams are graded on the content and format of their poster, their ability to use it to orally communicate the results of their project, and the technical merits of the project. We have found posters to be an ideal way to accomplish this evaluation. Both students and the Advisory Group members prefer it to the oral slide presentations used in the past because of the teaching moments created by the interactive nature of poster presentations. Advisory group members are able to home in on areas of particular interest to them, and students are able to glean valuable insights from the Advisory Group. An example of a student poster is shown in Figure 1. Names and advisor information have been removed from this figure.

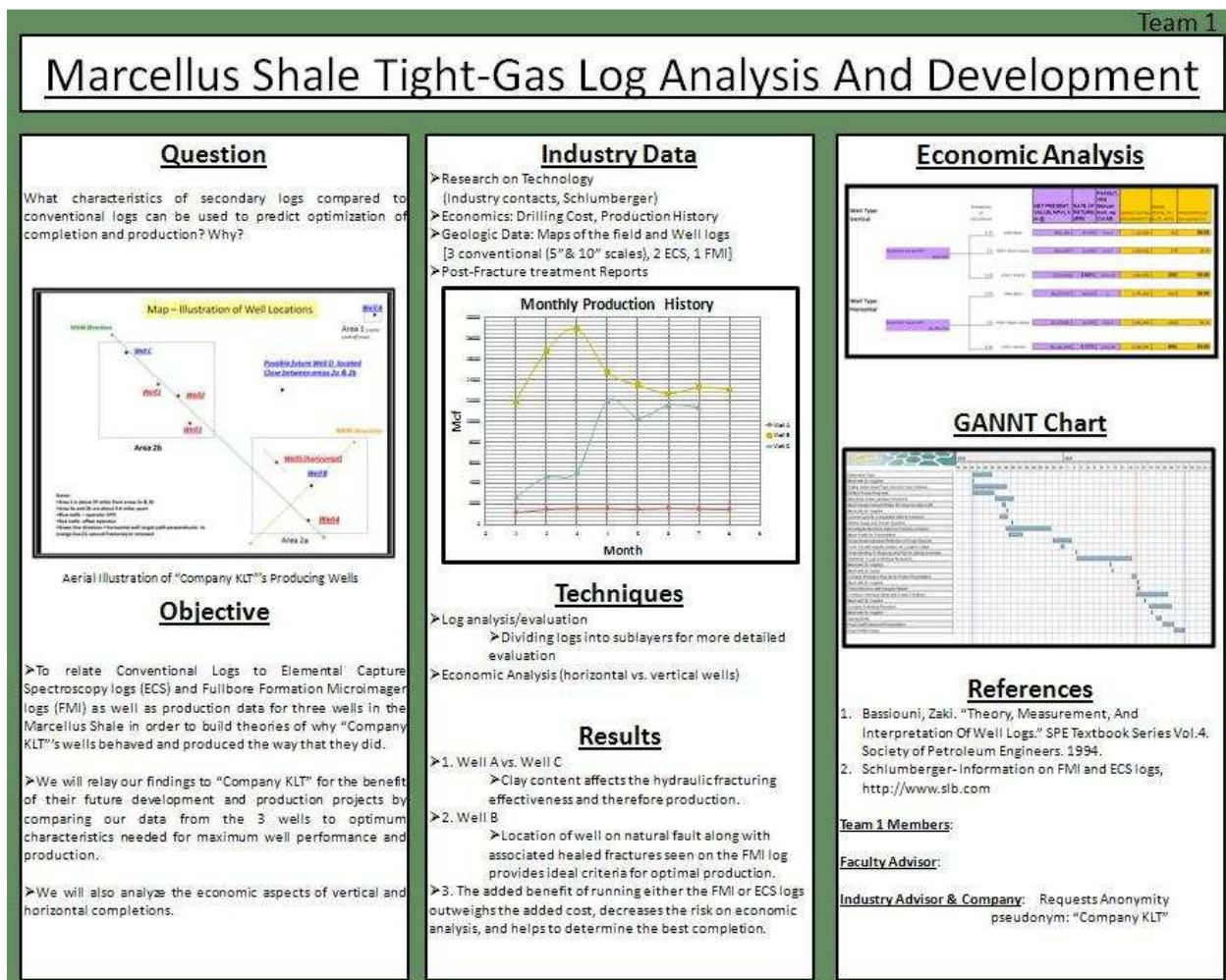


Figure 1 - Example of Completed Project Poster.

Engineering Ethics Videos. A second visual communication assignment employed video to express understanding of engineering ethics, with emphasis on situations that may be encountered in Biological Engineering. Student groups developed a script depicting a potential ethical dilemma in engineering, then used video recording and editing to create a movie clip

illustrating their script. The goal was to achieve a two-minute final video clip that would be loaded on a limited-access server permitting class participants to view each group's production.

Groups were assigned the video production project to achieve various outcomes: better understanding of potential ethical dilemmas (along with the applicable codes for addressing such a dilemma), instructional opportunity to "teach" that concept to other students in the class, evaluation of team interaction prior to selection of teams for their senior design project sequence and proposal preparation, development of video editing techniques for future job and project benefits, and better understanding of the communication potential of time-limited video. The Studio's high-definition video cameras and video editing software were critical equipment in the completion of these projects. Additionally, Studio staff and student mentors were available to help student groups learn basic video capture techniques and subsequent editing to produce a final product. Students received an in-class presentation by a Studio instructor on basic script writing, filming techniques, storyboarding, and common pitfalls the novice filmmaker is likely to encounter.

Figure 2 is a frame from one such video production in which the student group examined the ethical considerations of human cloning.



Figure 2 – Frame from Video Exploring Ethical Dilemma with Human Cloning.

CAD Modeling and 3-D Prototyping. In our third example of a visual communication assignment, students were assigned projects to design custom models that integrate with existing parts using SolidWorks™. Once the models had been created, a few were selected to be built using the Studio's 3-D printer, which uses a fused deposition modeling process to yield ABS plastic products. We found that when students have the opportunity to create a prototype with the 3-D printer, it further engages the student in the model's creation and design. Questions like "Can this model really be built?" or "Will this design integrate with another part?" become more important to the student. These are tangible 3-D models that students can hold in their hands. No longer are students working in a strictly virtual world with only computer models. Therefore, the design becomes more significant to the student. Figure 3 shows one such model in which a design flaw was discovered in the designed part only after it was printed. The white

material in this figure is the plastic model while the darker colored material is water soluble support material. The flaw is a discontinuity, visible as a horizontal line (circled in red) of support material running through the model, which will yield two separate parts when the support material is removed.



Figure 3 – 3D Prototype Model Produced from Student’s CAD File.

In the past, students would create designs without thinking critically about how they would be built and if they would really work. Now the burden of viability is placed on the student because of the 3-D model. “Will it work?” is a question that can now be answered once the model is printed. “Will it integrate with other parts?” is another question with a definitive answer with 3-D models. We have found that once a student’s model has been selected for printing, the student’s interest in the model design and function increases. The student is aware that within a short time we will all know if the model is buildable and workable. This process of moving from a computer model to a printed 3-D model has increased both student interest and effort toward the design of their projects, as well as an improved understanding of project feasibility.

Distinguished Communicator Certification

Distinguished Communicator Certification is a unique academic excellence program where students work to refine their communication skills and learn discipline-specific approaches to communication that will enable them to excel in their chosen professions. Each candidate is required to build a digital portfolio, demonstrating proficiency in written, spoken, visual, and

technological communication. Candidates must also show successful use of their communication skills in leadership roles and community service. Upon successful completion of the program, these students possess the competitive skills and knowledge needed for 21st century leadership. This coveted designation becomes part of official transcripts and gives the certified graduate significant leverage in today's job market. In order to earn certification, students must

- Earn a B or higher in at least 4 C-I courses – minimum 3 written, 2 spoken, 1 visual & 1 technical
- Complete an agreement with a faculty advisor and meet regularly to ensure timely submission of all components needed for certification
- Participate in and reflect on an internship(s), research, or study abroad experience related to their fields in which they exhibit strong communication skills
- Serve in and reflect on a leadership role(s) on campus (student organization or service-learning opportunities) or within the community
- Attend at least 3 workshops designed to improve communication skills
- Compile a private portfolio of required communication samples
- Complete an approved public portfolio showcasing individual communication skills
- Be in good academic and disciplinary standing with the university.

Engineering students have enthusiastically embraced this program. As of this writing, 175 Distinguished Communicator awards have been made campus-wide; of these, 68 (39%) have been awarded to engineering students, far more any other college on campus. Figure 4 shows Fall 2010 engineering students at a ceremony where they were presented Distinguished Communicator medals.



Figure 4 – Fall 2010 Engineering Distinguished Communicator Awardees.

While only a fraction of students earn the certification, it is noteworthy that all College of Engineering curricula include one and some as many as seven C-I designated courses. This directly supports ABET criterion for effective communication. Figure 5 shows the growth in the number of students registered in engineering C-I courses each semester since the inception of the program.

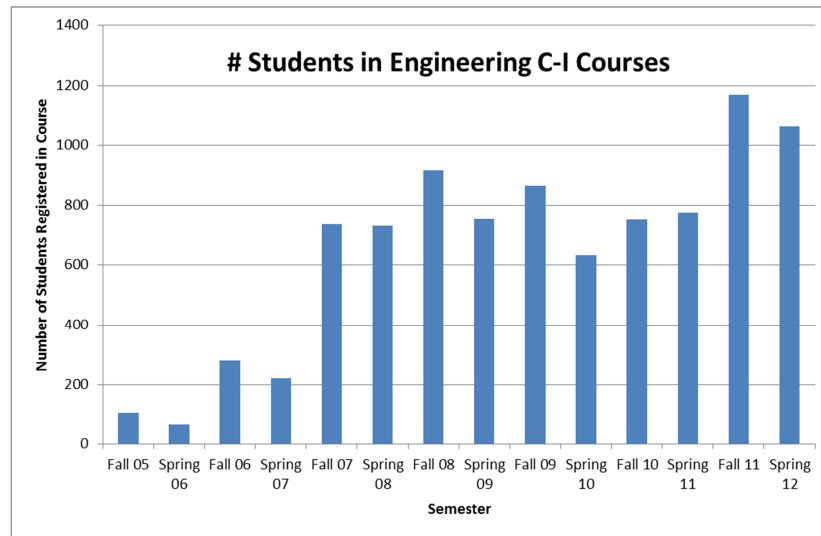


Figure 5 – Number of Students Registered in Engineering C-I Courses by Semester.

Engineering Communication Studio

Another key component in the program was the establishment of communication studios in the various LSU colleges. The first of these, the Engineering Communication Studio, was opened in the fall of 2005. 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 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 6. 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 6 – Studio Informal Lounge.

A conference room (Figure 7) in the Studio is equipped for critiques of oral presentations, one of the requirements of many C-I courses. The conference room is equipped with 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. The conference room SmartBoard™ also facilitates senior design group interaction with sponsors from industry through the use of installed remote conferencing software such as Skype™, GoToMeeting™, and GoToWebinar™.



Figure 7 - 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 are available for groups to move throughout the informal lounge.

The Studio's three-dimensional (3-D) printer 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.

A large-format printer 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 students, faculty, and staff to create poster drafts in grayscale before printing in color on glossy paper.

To further support students and faculty, the Studio is staffed with a Manager, who is a senior engineer, and a Communication Instructor who also has a faculty appointment in the English Department. These professionals work directly with students and faculty to enhance students' 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 College of Engineering (COE). One goal of the program is to facilitate more on-site tutoring from other programs so that their assistance will also be perceived as more relevant to engineering students.

Another goal is to create a resource that students readily embrace. The Studio employs more than 20 student workers, all engineering majors, who not only help extend the operating hours but also act as student mentors. Daily student visits are compiled by student workers using AccuTrack™ software at a computer workstation at the Studio entrance. Figure 8 shows daily and weekly student visits for the fall 2011 semester. Student visits typically peak at over 500 per week near the end of the semester when assignments are due.

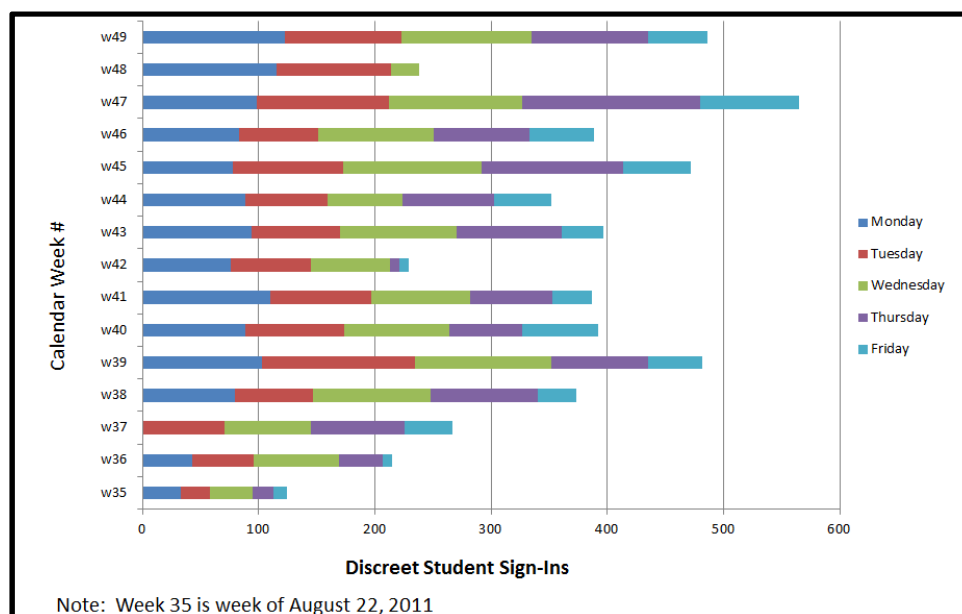


Figure 8 – Weekly and Daily Studio Visits, Fall 2011.

Summer Faculty Institute

A critical initial step in integrating specific communication skills into the COE was to identify a core faculty group representing each department. This core group of 11 faculty members prepared for a leadership role in the communication project by attending a Faculty Summer Institute during the summer of 2005. The engineering team received a comprehensive orientation to the campus-wide 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 projects such as the development of a communication studio for the COE. They shared their ideas about the college's need for communication skills and their newly-revised syllabi with faculty members representing all colleges at LSU, who provided an interdisciplinary audience for their ideas. This orientation was supplemented with presentations by recognized leaders in the various aspects of communication from other major universities (MIT, Missouri, George Mason, and Clemson).

Subsequent Summer Faculty Institutes have relied upon faculty from within our own university who have taught C-I courses to help champion the initiative. The focus of these Summer Institutes has been on various topics, including

- Employing assessment strategies in the four communications modes: oral, written, visual, and technological,
- Design and implementation of innovative, discipline-specific assignments and rubrics for each communication mode,
- Integrating iterative assessment effectively throughout the course of a project and a semester,
- Balancing and/or reducing workload requirements of a C-I course,
- Understanding that 40% of the grade based on communication milestones does not mean less emphasis on technical content, and
- Mitigating student resistance and developing productive classroom environment.

Since its inception, 47 of the roughly 110 teaching COE faculty members have participated in the Summer Faculty Institute.

Program Assessment

At the inception of this program, it was recognized that assessment had to have several goals. Although traditionally we must assess student achievement, other aspects of this program are also of vital importance to ensure program sustainability. Questions that must be answered are these: does participation in the CxC program increase faculty workload, are students resistant to new teaching methodology, have we focused on developing key transferrable skills, and is there adequate return on the program resource investment? Hence, a combination of assessment methods has been utilized.

Industry Advisory Body. An Engineering Communication Advisory Council was formed in 2006 to provide an independent review of ongoing initiatives to improve graduating engineers' communications skills. The Council is a small group of engineers who hold senior-level positions in government and private industry and 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. The Council convenes formally as a group on a semi-annual basis to review examples of the communication-intensive projects produced by sophomore and senior design classes. Between scheduled meetings, additional interactions occur between Council members and the Studio staff. Examples of these interactions are reviews of examples of students' written reports and occasional attendance at scheduled oral presentations by students.

Given the Council members' senior positions in their organizations, they bring a unique understanding of skills required for success in the engineering profession, not only communications skills but also skills required for success in the global engineering environment. Members of the Council have proven to be a valuable source of unbiased assessment of communications and team-oriented programs initiated in the College of Engineering. Council members have offered candid observations and pointed recommendations resulting in significant program improvements.

For example, during the December 2010 meeting, the Council expressed concern regarding the preparation that our students receive to enable them to be successful in the increasingly global environment that engineers encounter upon graduation. Council members observed that we have successfully integrated communications skills into the engineering curriculum and asked whether this conceptual approach could be applied to cultural and global awareness? Our response is showing considerable promise in its early stages.

Student Surveys. Questionnaires have been utilized to assess student perceptions and attitudes regarding C-I courses. These have been presented to students as end-of-course queries for all engineering C-I courses. The results shown in Figures 9-11 are responses gathered at the end of spring 2008 semester. For Figures 9 and 10, students were given a 5-point scale to record their responses. These positive results show that students appreciate the skills learned in the course.

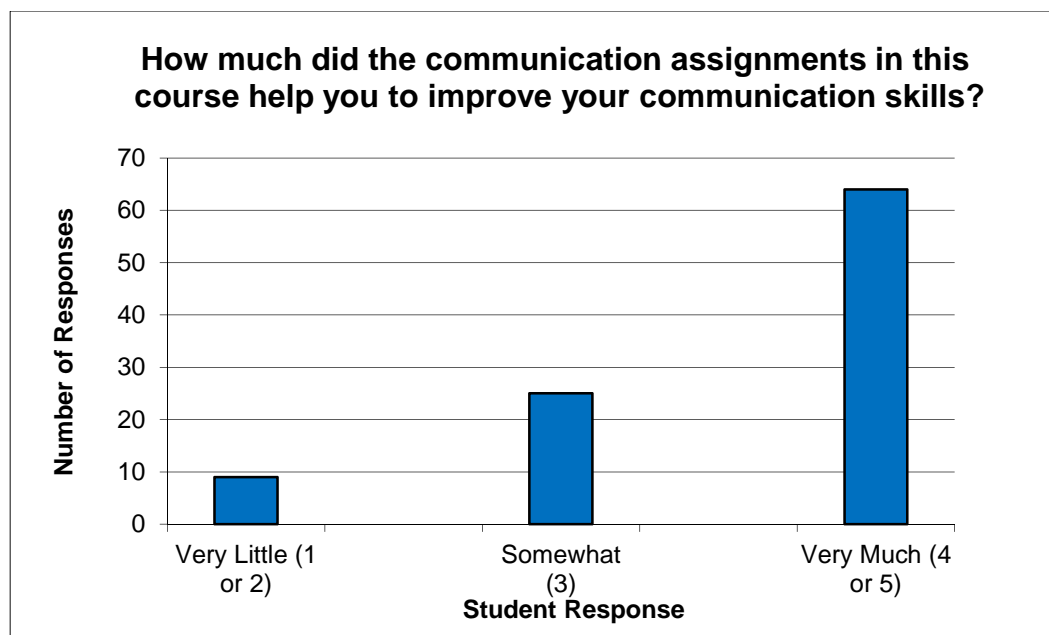


Figure 9 – Student survey responses (n = 97).

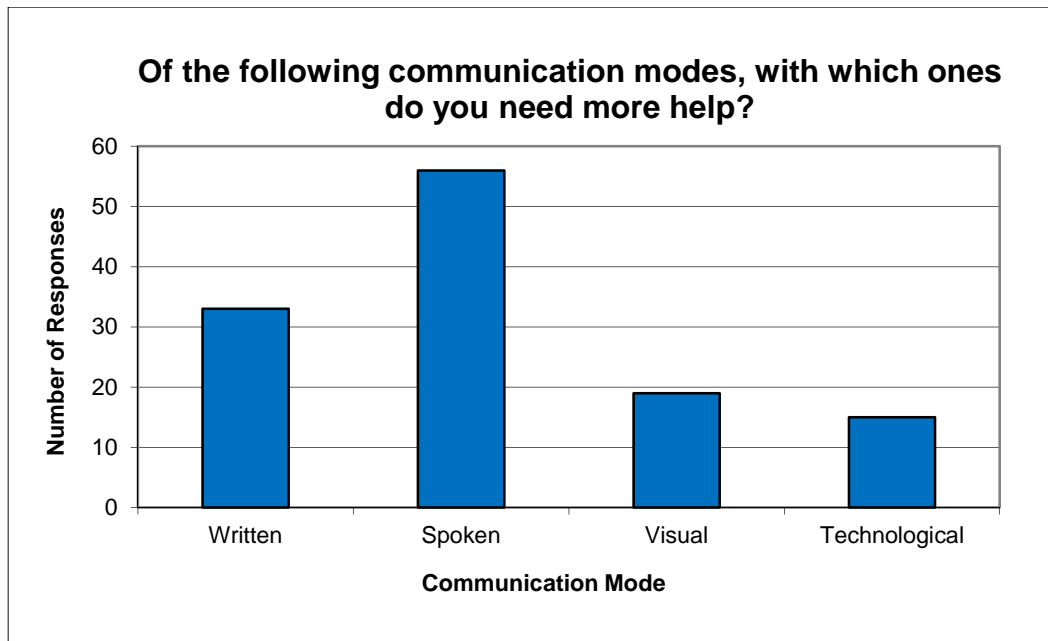


Figure 10 – Student survey responses (n = 98).

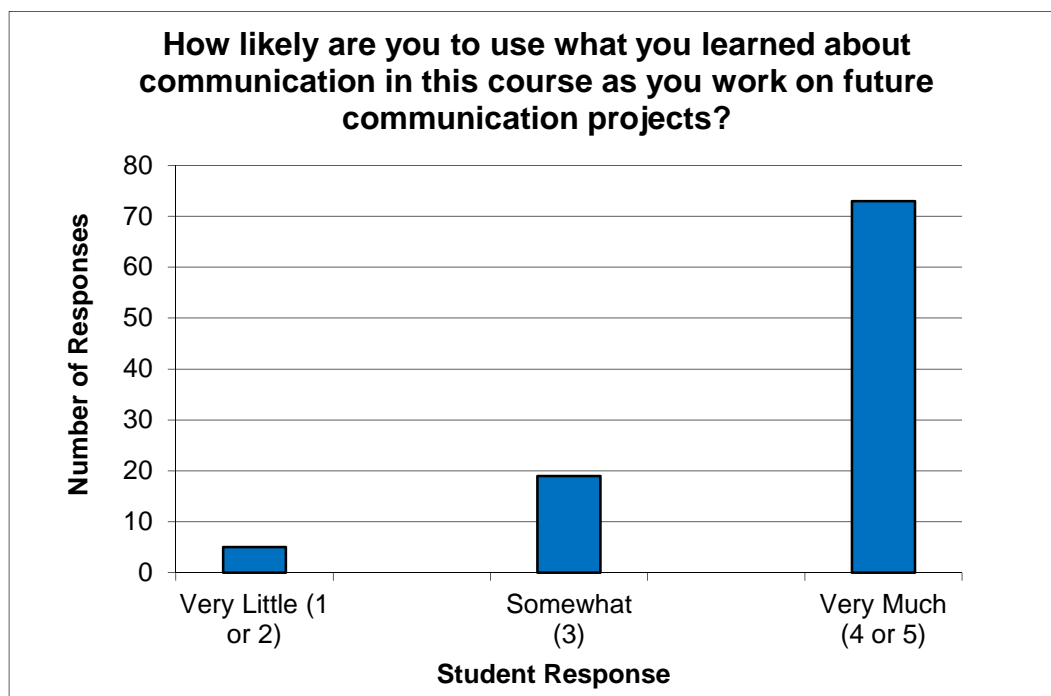


Figure 11 – Student survey responses (n = 123).

Figure 11 shows the students' perceptions of the communication skills for which they feel they need additional help.

Faculty Survey. A survey of faculty who had taught a C-I course (2007-2008) yielded the results shown in the following figures. Faculty found that the workload involved in teaching a

Communication-Intensive course was not similar to teaching the same course without a communication emphasis (Figure 12). In post-survey interviews, faculty consistently reported that additional time investment was required for teaching C-I courses. Faculty also indicated that additional workload was required of the students (Figure 13). The student workload increase was a concern for us; however, we have not experienced any noticeable push back from students regarding C-I courses. The increasing number of students participating in engineering C-I courses that we showed in Figure 5 indicates to us that there is a growing acceptance of this teaching mode.

We were encouraged that faculty thought that technical content was not sacrificed (Figure 14), and indeed, they felt that students learned the technical content in more depth versus being taught in a traditional mode (Figure 15). We found a mixed response regarding the faculty members' perception of how well improved the students' communication skills were as a result of the C-I course (Figure 16). During follow up interviews with faculty, we observed that many engineering faculty members were hesitant to assess improvements in students' communication skills because they didn't feel qualified to make such an assessment.

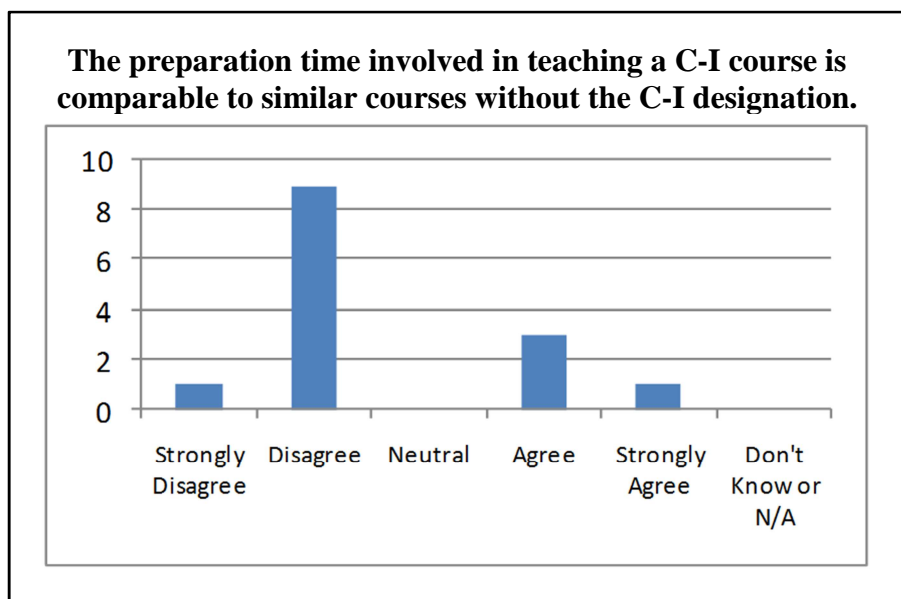


Figure 12 – Faculty who taught C-I courses responses (n = 14).

The student workload involved in taking a C-I course is comparable to similar courses without the C-I designation.

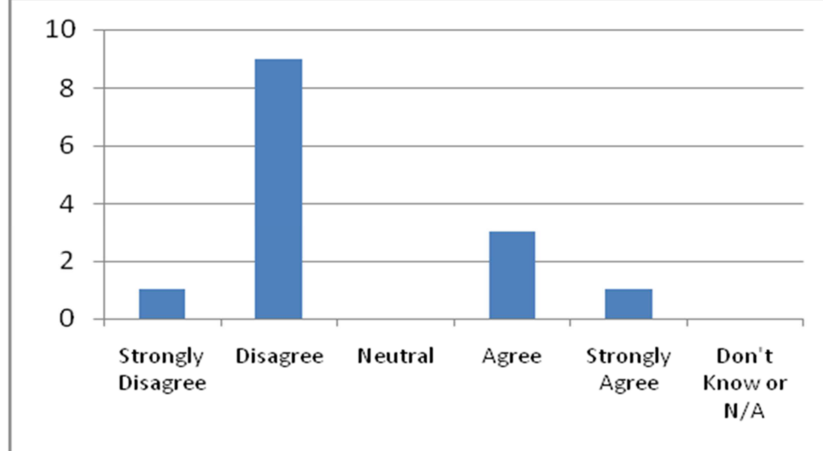


Figure 13 – Faculty who taught C-I courses responses (n = 14).

Course content was not sacrificed in order to meet the communication requirements for C-I designation.

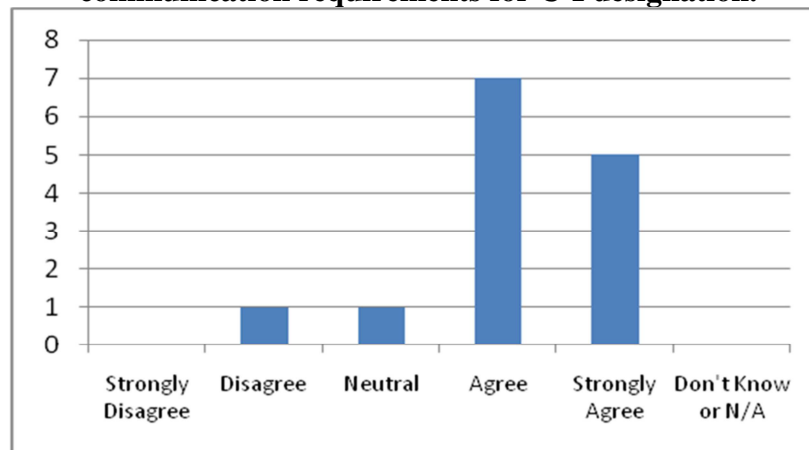


Figure 14 – Faculty who taught C-I courses responses (n = 14).

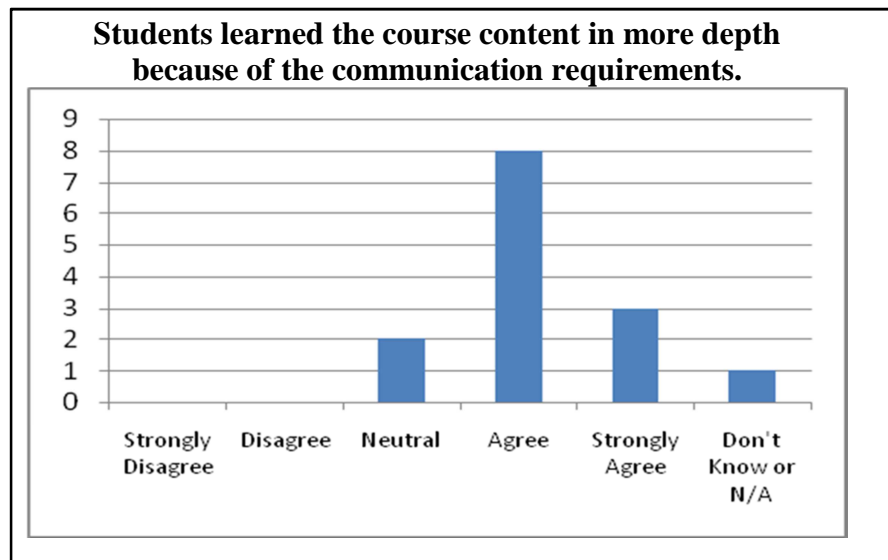


Figure 15 – Faculty who taught C-I courses responses (n = 14).

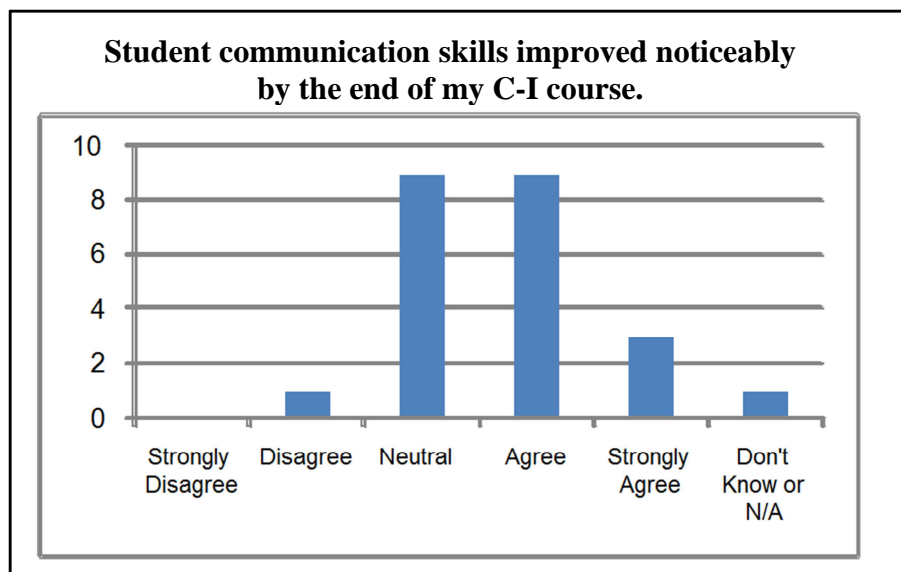


Figure 16 – Faculty who taught C-I courses responses (n = 23).

Return on Investment. Although the communications integration program was initially funded by a gift, the ongoing commitment of resources must be routinely assessed, particularly in an austere funding environment. This was explored in detail in our 2009 paper.⁶ Our approach was to compare this innovative investment to that which has been relied upon historically. This historical reliance had fallen primarily to requiring a technical writing course in each of the engineering discipline tracts. In 2005, a coincidental circumstance occurred that had a major impact upon technical writing courses.

Our university encountered steady growth of non-tenure track instructors in the English Department to meet the demands of growing enrollment. The subsequent ratio of tenure track to

non-tenure track faculty was viewed as an undesirable situation for a major research university; therefore, it was deemed necessary to reduce the large number of non-tenure track instructors. Of course, this decision required major restructuring of the English Department, which severely reduced the technical writing courses being offered. Since engineering required these courses for all of its degree programs, this change forced a re-thinking of how students would receive this type of instruction.

The loss of technical writing was not viewed as a major problem by all. Rather many engineering faculty members had already questioned the value of a technical course taught by non-engineering faculty. Among the issues raised were the following:

- Resource investment. With an average of eight sections per semester in the English Department committed to teaching technical writing, one had to wonder whether the university was getting a commensurate return for its investment in these instructors.
- Consistency of teaching. College of Engineering (COE) faculty who assigned written work in their courses observed that some students showed stark deficiencies in their grasp of technical writing, even after successful completion of the technical writing course.
- Engineering faculty engagement. With the large number of instructors teaching these courses, and the fact that they resided in another college, many COE faculty felt that they had little input to the curricular requirements. It must also be observed that most engineering faculty members did not feel that it was their role to dictate writing requirements in these courses.
- Only one communication skill addressed. As the name implies, the focus of these courses was entirely on the written communication skills. This is the most significant limitation. Oral communication was typically addressed as an elective course, requiring students to choose any one of several speech electives. Visual and technical communications skills were seldom addressed.

Armed with student and faculty evaluations of C-I courses and the rapid growth of these courses in each of the engineering disciplines, we reached the following positive conclusions:

- Reaching far more students comprehensively. While a single required technical writing course could conceivably capture each student, this one-semester exposure pales in comparison to the broad range of C-I courses that COE students are now experiencing throughout their curricula. This collection of courses assures that communications skills are taught and reinforced over much of the students' undergraduate experience.
- Additional communication skills taught. All C-I courses require that at least two communication modes be included in the course requirements, therefore, expanding the skill set well beyond the written mode and addressing the students' request to be taught additional modes of communication, especially speaking, as shown in Figure 11 above.

- Engineering faculty members engaged. COE faculty members have adapted syllabi to incorporate communication skills. Although they concede that teaching communication skills does often require additional work, assessment of faculty attitudes shows that they typically believe the students have learned course content at a higher level.

Conclusions and Future Work

While we conclude that our program has successfully integrated communication skills into the engineering curriculum with efficient resource investments, we continue to investigate methods to better assess this success. Creating more comprehensive surveys of students and faculty who participate in C-I courses is one tactic; however, we are wary of attempting complex, time-consuming questionnaires. Instead, we believe that surveys should be undertaken of two populations:

- Recent engineering graduates. By recent, we would define the population as graduates since 2006, the completion of our first full year of C-I course implementation. Of interest would be their perception of their communication skills development in the academic environment, e.g., how well did these skills meet their professional demands, what is their perception of their communication skills compared to graduates of other engineering schools, and what would they like to have mastered better.
- Employers and Graduate School Advisors. We would be similarly interested in their perception of our graduates' communications skills and how they compare to graduates of other schools. Additionally, we would ask their candid assessment of weaknesses in our graduates' communications skills.

Information from these studies would enable us to make a solid CxC program even stronger. We are also confident that this model can be used for integrating global awareness into the engineering curricula and have initiated this program. We expect to report our findings in a future paper.

References

- [1] Engineering Accreditation Commission, Criteria for Accrediting Engineering Programs Effective for Evaluations During the 2005-2006 Accreditation Cycle, Accreditation Board for Engineering and Technology, Inc., Report, Nov. 2004.
- [2] Committee on Engineering Accreditation, Initial Assessment of the Impact of ABET/EC2000 Implementation Using Mechanical Engineering Programs as the Pilot Study Group, R. Laurenson, ed., American Society of Mechanical Engineers, Report, Dec. 2001.
- [3] Committee on the Engineer of 2020, Phase II, Committee on Engineering Education, National Academy of Engineering. "3 Getting to 2020: Guiding Strategies." Educating the Engineer of 2020: Adapting Engineering Education to the New Century. Washington, DC: The National Academies Press, 2005.
- [4] ASCE Steering Committee to Plan a Summit on the Future of the Civil Engineering Profession in 2025, American Society of Civil Engineers. The Vision for Civil Engineering in 2025. American Society of Civil

Engineers. [Online] Available:http://www.asce.org/uploadedFiles/Vision_2025_-_New/TheVisionforCivilEngineeringin2025_ASCE.pdf . [Cited December, 2012].

[5] Waggenspack, W.N., Hull, W. R., Bridwell-Bowles, L., Farrell, J., Bowles, D. “Implementing Informal Writing Assignments and a Written Feedback and Revision Loop to Enhance Learning in Engineering Courses.” Proceedings of the 2008 Annual Conference of the American Society for Engineering Education. June 2008.

[6] Waggenspack, W.N., Liggett, S., Hull, W.R., Bowles, D.F., Sears, S., Thomas, D., Davis, P. “Incorporating Visual Communications Assignments to Enrich Education in All Engineering Disciplines.” Proceedings of the 2010 Annual Conference of the American Society for Engineering Education. June 2010.

[7] Hull, W.R., Waggenspack, W.N., Bridwell-Bowles, L., Bowles, D., Choplin, T. “An Innovative Model for Teaching Communications Skills In the Engineering Curriculum” Proceedings of the 2009 Annual Conference of the American Society for Engineering Education. June 2009.