AC 2010-737: INCORPORATING VISUAL COMMUNICATIONS ASSIGNMENTS TO ENRICH EDUCATION IN ALL ENGINEERING DISCIPLINES

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Incorporating Visual Communications Assignments to Enrich Education in All Engineering Disciplines

Introduction

At Louisiana State University, a gift from an alumnus made possible the establishment of a program to improve students' communication skills. As we described in a 2006 paper, the Communication across the Curriculum (CxC) Program was established in 2004 with an initial emphasis on engineering students.¹ One of the key elements of the CxC program was the inception of Communication-Intensive (C-I) Courses. C-I courses are intended to be integrated into existing discipline-specific courses, with additional requirements for emphasis on two of the four modes of communication: written, spoken, visual (the focus of this paper), and technological. In a 2007 survey designed to solicit student perceptions of the value of C-I courses in the engineering curricula, students overwhelmingly agreed that the assignments contributed to their communication skills, and that these skills were important to their future careers in engineering.² Faculty assessment of C-I courses in 2008 showed that workload increased somewhat for both faculty and students in C-I courses; however, it was also acknowledged that students' knowledge of traditional course content was enhanced.³

Another key element in the CxC program was the establishment of communication studios in the various colleges. The first of these, the Engineering Communication Studio (Studio), was opened in the fall of 2005. This 2000 ft² facility and its use by students and faculty were described in detail in a 2007 paper.⁴ The Studio has state-of-the-art technology applications at 17 computer work stations and comfortable lounge seating for an Internet café atmosphere. A conference room in the Studio is equipped to support critiques of oral presentations, one requirement of many C-I courses.

A valuable resource is the Studio's three-dimensional (3-D) printer, which enables students to see their designs come to life by creating a functional ABS plastic model directly from design files. Additionally, a large-format printer allows students to create posters and CAD drawings in formats up to 42 inches wide. To aid in the development of communication projects, the Studio offers a wide range of audio-visual resources for student checkout. These resources include still and video cameras, wireless and corded microphone systems, and highly portable projectors and projection screens.

The campus-wide CxC program and the Studio comprise a sustained support system for engineering students and faculty. This has contributed to enthusiastic acceptance of programmatic changes by both faculty and students and helped the engineering program meet ABET's criterion for Program Outcomes, which states that students must demonstrate an "ability to communicate effectively."⁵ Traditionally, this outcome has been assessed by examining students' writing and speaking skills. However, as this paper shows, organizations such as the National Academy of Engineering are stressing the necessity for students to develop visual communication skills as well. Because of the requirements of C-I courses (emphasizing two of the four modes) and because of the technologies and instruction available to students in the Studio, the CxC program in Engineering has enhanced its instruction in visual communication

through three projects: senior design posters, engineering ethics videos, and CAD modeling and 3-D prototyping. These assignments are intended to teach students ways to visually communicate their innovative solutions to engineering problems.

Building on the Process

Through self-assessment of the program, we realized that much of our past work centered on communication in written and oral modes, whereas graphical depiction of data is a means of visual communication that is ubiquitous throughout engineering. Likewise, the development of models and drawings using computer-aided design software is considered to be a mainstay of visual communication in engineering curricula. Just how and why visual communication should be taught and applied in engineering C-I courses led us to examine perceived future directions in engineering education.

We found a valuable source in the 2004 National Academy of Engineering (NAE) report on the future of engineering.⁶ We were particularly interested in the following observation (emphasis added):

Creativity (invention, innovation, thinking outside the box, art) is an indispensable quality for engineering, and given the growing scope of the challenges ahead and the complexity and diversity of the technologies of the 21st century, creativity will grow in importance. The *creativity requisite for engineering will change only in the sense that the problems to be solved may require synthesis of a broader range of interdisciplinary knowledge* and a greater focus on systemic constructs and outcomes.

As would be expected, this NAE report also highlighted the value of good communication skills for future engineers; however, we were intrigued by the following quote (again, emphasis added):

We envision a world where communication is enabled by an ability to listen effectively as well as to communicate through oral, visual, and written mechanisms. *Modern advances in technology will necessitate the effective use of virtual communication tools.*

When examining these NAE observations for potential impacts on our communication integration process, we believed that we needed to further investigate visual communication tools. This decision was confirmed when we reviewed the follow-up 2005 NAE report that examined the education implications of its previous report.⁷ Once again, we will quote:

Rapid advancements in the years ahead could enable new learning environments using simulations, visualizations, immersive environments, game playing, intelligent tutors and avatars, networks of learning, reusable building blocks of content, and more.

Using these observations, we initially chose to enhance our visual communication integrations program with the three initiatives described below.

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 Studio 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 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 were able to home in on areas of particular interest to them, and students were able to glean valuable insights from the Advisory Group. Examples of students' posters are shown in Figures 1 and 2. Names and advisor information have been removed from these figures.



Figure 1 - Example of Completed Project Presentation.



Figure 2 - Example of Completed Project Presentation.

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.

The overall goal of assigning a video production project to groups was multi-dimensional, including the following outcomes: better understanding of potential ethical dilemmas (along with the applicable codes for addressing such a dilemma), pushing students to "teach" that concept for all other students in the class, evaluation of team interaction prior to selection of teams for their senior design project sequence and proposal preparation, obtaining additional knowledge of video editing approaches for future job and project benefits, and gaining a better understanding of the communication potential of time-limited video.

It is significant to note that the availability of the Studio's high-definition video cameras and video editing software was a critical element in the completion of these projects. Additionally, Studio staff and student mentors were available to student groups to help them learn basic video capture techniques and subsequent editing to produce a final product. Students received an inclass presentation by a Studio instructor on basic script writing, filming techniques, storyboarding, and common pitfalls the novice filmmaker is likely to encounter.

Figure 3 is a frame from one such video production in which the student group examined the ethical considerations of human cloning. Figure 4 is a frame from another video production in which the student group illustrated the ethical issues and potential impacts of public officials accepting gratuities from bidders during a public solicitation process.



Figure 3 – Frame from Video Exploring Ethical Dilemma with Human Cloning



Figure 4 – Frame from Video Examining Acceptance of Gratuities

CAD Modeling and 3-D Prototyping

In our third example, students were assigned projects to design custom models that integrate with existing parts using SolidWorksTM. Once the models had been created, a few were selected to be built using the Studio's 3-D printer, which utilizes 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 5 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 of support material is removed.



Figure 5 – 3D Prototype Model Produced from Student's CAD File

In the past, students would create designs without seriously thinking about how it would be built and if it 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 that has 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.

Summary and Future Directions

We are encouraged by positive student responses to our initiatives to integrate visual communication projects into various engineering courses. This effort, as well as other communication initiatives, also received positive comments during the fall 2009 ABET review of our engineering curriculum. However, one recognized need is to develop a more consistent approach to evaluating students' visual communication projects. To meet this need, we are actively developing an extension for Calibrated Peer Review (CPRTM). CPR is an online application that enables students to critically review other students' written assignments as a

learning tool for their own written work. Our goal is to extend this tool to both visual and oral communication assignments.

Another recognized need is to continually review the adequacy of the Studio's resources to meet faculty and student requirements. This review recently led us to upgrade our 3-D printer to one that is faster and capable of higher precision than our previous model. We are also monitoring Studio use to determine whether current floor space is adequate to support the increased demands of students. Utilization trends now indicate that we are rapidly approaching a saturation point with our current facility. We are hopeful that appropriate strategic planning will enable us to maintain the future viability of the Studio and our communication initiatives to prepare students to use 21st century technologies.

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