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It Takes The Whole University To Instruct The Whole Engineer: Narratives Of Collaboration

Abstract

Collaborations between engineering faculty and skilled experts outside of engineering proper build strong undergraduate engineering curricula that clearly emphasize professional skills and ABET program outcomes (Criteria 3 d, f, g, h, i,). With shared goals of providing undergraduates with a rich educational experience in which research, communication and critical thinking are central to achievement and to the development of integrity in engineering, such collaborations produce an instructional program that readies students for the requirements of continuous learning and complex analysis essential to a successful, principled engineering career.

This paper will describe the contributions to undergraduate engineering education that non-engineering faculty and academic departments have brought to the Pitt Experience. We will emphasize the process of designing curriculum with multiple learning outcomes that address a broad range of professional and academic goals, and we will provide examples of assignments and tools, developed by instructors and librarians from across curricula, that support research, communication, and critical thinking towards educating the "whole engineer."

"When students leave the university unable to find words to render their experience, they are radically impoverished."[1]

Introduction: The Collaborative Whole

Current ABET accreditation requirements emphasize the importance of "soft" skills in planning and achieving excellence in engineering education. What engineers need to experience and know, in addition to "hard" knowledge, is further explained by Shuman and Besterfield-Sacre as "process-oriented skills and awareness-oriented skills."[2] Process-oriented skills include "communication, teamwork, and the ability to recognize and resolve ethical dilemmas."[3] These skills are powerful when combined with awareness skills involving "understanding the impact of global and social factors, knowledge of contemporary issues, and the ability to do lifelong learning."[4] But what are the most effective ways of incorporating process and awareness-oriented practices into engineering curricula already crowded with necessary science, math, and disciplinary courses? How can engineering schools, which must ensure that their students graduate with sound hard skills, also ensure they are graduating "whole engineers"—engineers who have encountered and practiced communication, teamwork, and the ability to recognize and resolve ethical dilemmas; who are cognizant of the potentially enormous social impact of engineering; and who have skills which facilitate lifelong learning in these very areas?

For engineering schools to educate "whole engineers," they must embrace their own university's whole range of resources. Schools of engineering are parts of larger educational institutions, and, as such, have the opportunity and obligation to make the best use of the resources a whole university has to offer. Here at the University of Pittsburgh, the Swanson School of Engineering faculty and administration have worked in tandem with librarians, with faculty from other departments (most notably English Composition), with the University's Office of Measurement and Evaluation of Teaching (OMET) and the Center for Instructional Development and Distance

Education (CIDDE) to develop tools and projects to educate students in process and awareness-oriented skills. To do so effectively, the Swanson School of Engineering has advocated and practiced the very skills it sees as essential to the "wholeness" that facilitates effective communication, teamwork, and responsible action. Two recently developed, successfully implemented "soft skills" programs—the English/Freshman Engineering Writing Program (E/FEWP), and the Information Skills for Engineers program (ISfE)—would not exist without teamwork and communication across schools, programs, and departments. As teams collaborated to develop and refine these programs, they consistently kept issues of educational and engineering ethics prominent. What follows in this paper are descriptions, or narratives, of how such collaborations created a genuinely "whole" program with the ongoing goal of educating whole engineers.

Collaboration in Action: (E/FEWP), History and Goals

Most freshmen entering the University of Pittsburgh, including those entering the Swanson School of Engineering, are required to take the University's core writing course, Seminar in Composition, during the freshman year. Freshman engineers are required to take a full load of math, science, and engineering courses, making it impossible to add another course to their freshman year. Given this problematic situation—that freshman engineering students, like all university freshman, are required to take Seminar in Composition, yet already have full course loads—Dr. Daniel Budny, Director of Freshman Engineering, spearheaded a collaboration between Pitt's English Department, the Swanson School of Engineering's Freshman Program, and the Bevier Engineering Library. Budny knew that the School of Engineering faculty had neither the time nor the pedagogical expertise in freshman composition to develop and teach an engineering equivalent to Seminar in Composition. With support from Dr. Larry Shuman, Engineering Dean of Academic Affairs, Budny engaged the expertise of experienced composition teachers to create and implement an equivalent to Arts & Sciences' Seminar in Composition. As a solution to the programmatic time restrictions, the composition course would become part of the fall semester's required Engineering Analysis class and the spring semester's required Engineering Problem Solving class. For this composition-within-engineering to succeed, all freshman engineering faculty had to be willing to open their classroom doors and their syllabi to the composition instructors and assignments. Composition instructors had to be willing to work within time frames and curricula different from the standard Arts & Sciences 3-credit course.

The Composition Program has a strong commitment to university-level literacies; the challenges and outcomes of developing a Seminar in Composition equivalent for freshman engineers that would be taught from within the freshman engineering curriculum was intriguing to composition faculty, especially those faculty who had experience with professional writing. Dr. David Bartholomae, English Department Chair, and Dr. Nicholas Coles, Director of Composition, both supported the English Freshman Engineering collaboration, seeing it as professionally enriching and as providing expected service to university students. In 2002, Beth Bateman Newborg, an English Department instructor with particular experience in teaching both composition and professional writing, joined Dr. Bartholomae in presenting the possibility of an engineering equivalent to Seminar in Composition to Dr. N. John Cooper, Dean of Arts & Sciences. Dean Cooper supported such a program with an ongoing appropriation of funds from Arts & Sciences.

Thus began the E/FEWP, a dynamic, collaborative program that continues to significantly contribute to educating whole engineers.

E/FEWP: Process, Practices, Outcomes

"Learners are most ready to learn when they have a real-life need to know something." [5]

To show the extent and nature of collaborations that ensure students meet crucial Composition Program and ABET objectives, we review here the development of the first 2 writing assignments freshman engineering students encounter. The actual E/FEWP writing assignments that all freshman engineering students must complete are available upon request.

E/FEWP: Assignment #1

Dan Budny has a program in which upperclassmen act as peer mentors to incoming freshmen. To gain a sense of their students' background, interests and accomplishments, the mentors ask the freshmen students to write letters of recommendation about themselves for an imaginary engineering scholarship. As the E/FEWP faculty, directed by Beth Newborg, began developing the program's curriculum, they immediately saw the usefulness of this peer mentoring exercise. The E/FEWP staff composed an assignment that intensified the "letter of recommendation" scenario and expectations. The students' engagement with the E/FEWP letter of recommendation assignment would now be a first step in meeting Composition Program goals of composing "thoughtfully crafted essays that position the writer's ideas among other views" and of "writ[ing] with precision, nuance, and awareness of textual conventions."[6] E/FEWP continued to collaborate with all Engineering Analysis faculty to refine and present the assignment in ways that would make the most sense to freshman engineers in their first weeks of engineering school. What began as an informal mentoring exercise was collaboratively developed into an engineering/composition experience rich with potential personal and academic learning outcomes.

E/FEWP: Assignment #2

Information literacy is defined by the Association of College and Research Libraries (ACRL) as the set of abilities requiring individuals to "recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information."[7] These abilities are essential to the process and awareness-oriented skills that are important for the whole engineer to acquire. Pitt's comprehensive course description for Seminar in Composition states that "As a step toward college-level critical literacy, this course is designed to help student writers become more engaged, imaginative, and disciplined composers, better equipped to handle complex subjects thoughtfully and to use sources responsibly."[8] To emerge from the freshman engineering year with the discipline and responsible practices of university-level literacies, it was essential to include research activities and researched-informed writing in the E/FEWP assignments.

Kate Thomes, Director of the Bevier Engineering Library, was well aware of the need to heighten engineering students' information literacy skills, and immediately became an essential expert contributor to the E/FWEP. The engineering librarians worked with the freshman

engineering faculty and E/FEWP faculty to develop assignments that introduced freshmen to a variety of resources and search methods. Assignment #2, "Identifying and Evaluating an Engineering Issue, Practice, Process, Product or Structure," requires that students clearly articulate their own evaluation of a recent engineering issue, practice, process, etc., but the students' descriptions and evaluations must be informed by responsible research. As with all the writing assignments that follow, Assignment#2 requires that students see the information literacy that informs responsible research as an integral part of the process of developing and articulating an evaluative position. Without library collaboration, the E/FEWP staff could not have included the information literacy learning and experience that are part of a successful "whole engineering" writing curriculum.

As the engineering librarians have continued with their research into effective information literacy initiatives that could be utilized throughout the school of engineering, they have supported and informed the goals of the E/FEWP in many ways. Rachel Callison's research and writing on literacy learning taking place most effectively in a "real-life need to know"[9] context has continued to shape and support E/FEWP assignments. E/FEWP and engineering faculty had always emphasized the value of creating assignments that directly addressed engineering topics and issues. Callison's research and findings will continue to inform the modeling of "real-life" situations—whether in the form of a professional letter, a paper on a current engineering product, a paper dealing with product-related ethical issues, or a conference paper—towards ensuring those skills and literacies essential to the "whole" engineer. Kate Joranson, a library and information sciences graduate student, has contributed to the refinement and reinforcement of E/FEWP practices with her research on Howard Gardner's work on "multiple intelligences." Gardner suggests that each human has a unique blend of intelligences, which may include a combination of logical/mathematic, linguistic, kinesthetic, spatial, interpersonal, and intrapersonal, among others.[10] These ideas bring us back to Shuman and Besterfield-Sacre's description of process and awareness-oriented skills. The E/FEWP will continue to seek Joranson's expertise on how to enhance the "wholeness" of goals and practices via a program that values diverse contribution and cross-trains us all to strengthen our understanding and capabilities in areas we find challenging.

Collaboration in Action II: ISfE History and Goals

Following the freshman year, engineering students disperse into various disciplinary departments. Without a cross-disciplinary research and writing program in place, enhancing process and awareness skills in the upper undergraduate years becomes a challenge. Sophomore, junior, and senior engineering students need ongoing professional skills training that ensures mastery of various literacies, including information literacy skills. Because there is no upper-level engineering course that all students take, we had to find a way to reach students in a variety of specialized courses. Steve Abramowitch, Assistant Professor of Bioengineering, describes the need for library research instruction:

"I have attempted to introduce students to some of the library resources that are available at the University. After a brief demonstration in class, I would have students obtain 5 literature sources that were relevant to their specific research project and write a report that summarized their content. While students were able to complete the assignment, I was well aware that I was not

exposing them to the breadth of information and resources that are available to them. Moreover, it was clear that the students had viewed my short instruction only as a means to complete that specific assignment and not as a skill-set that they could utilize in future courses and beyond.

"I was able to experience an example of the latter point as I guest lectured the last quarter of a senior level Biomechanics course [in 2005]. A few of the students in the class were students I had previously instructed as juniors in BioE 1002. The students were given an assignment to write a report on a research project that they would like to conduct based on the materials covered in class. I was disappointed when a number of the seniors that I had previously instructed approached me for help in starting the assignment. After asking these students what they think would be a good first step, none of them had thought of exploring the relevant literature on a topic. Even when I suggested that they should do so, they had difficulty remembering how. It was only after I reintroduced them to searching databases such as Scopus, Medline, etc., that they realized how to proceed. This experience clearly highlighted that our students, even as seniors, had not benefited from the brief instruction on library skills that was being provided by our previous curriculum."[11]

To address these concerns, and to build on the solid information literacy foundation laid by E/FEWP in the freshman year, the Bevier Engineering Library proposed a program to systematically integrate library research and information literacy into the upper level undergraduate curriculum. The Information Skills for Engineers program (ISfE) started in 2005 with the idea of creating curriculum that could be used by faculty in upper-level courses to teach library research and the ethical use of information. Goals of this ISfE curriculum include supporting existing engineering research assignments and projects, and infusing those assignments with information literacy skills. By emphasizing library research and the ethical use of information, these skills are situated in a "real-life" and point-of-need context.

ISfE: Processes, Practices, Outcomes

ISfE began as a lecture-implemented program, then moved into an online format. Throughout both of these stages, ISfE has benefited from input and revisions by professionals throughout the university. Looking back to the initial stages of ISfE, developing instructional objectives and learning outcomes was key. Following a close reading of accreditation standards and information literacy standards from ABET, ACRL, and the Middle States Commission on Higher Education, the librarians articulated five objectives to guide ISfE curriculum development:

1. Determine the nature and extent of information needed for a project
2. Access information effectively and efficiently
3. Evaluate and understand the information
4. Use information ethically
5. Use research to create new knowledge

ABET criterion 3 on Program Outcomes and Assessment (especially parts d, f, g, h, and i) broadly state the learning objectives above and more specific articulation of the objectives comes from the ACRL and Middle States.

Working from the desired learning outcomes, the librarians developed lecture-based materials that taught upper-level students how to search for information beyond what is available on the Internet, key research tools for different fields of engineering, the nature of various types of engineering literature, critical evaluation of information, proper citation, and avoidance of plagiarism. Engineering faculty and librarians worked together to develop course-integrated assignments that measured the students' comprehension of the concepts and tools presented.

In these early stages of ISfE, Kate Thomes, the engineering librarian, worked with Pitt's Office of Measurement and Evaluation of Teaching (OMET) to develop tests to measure student learning of the concepts in the new curriculum. With input from OMET, the engineering librarian developed multiple-choice tests based on the student learning objectives. An item analysis of the pre-test data was used to identify concepts that needed to be emphasized within the curriculum, or that could be dropped because students had already mastered them. Comparative analysis of the pre/post test data demonstrated that the ISfE curriculum was effective in improving student understanding of the material. OMET's assistance in interpreting the test data allowed the librarian to communicate effectively with engineering administrators and faculty about the success of the ISfE program. This collaboration was valuable both in helping to create valid assessment instruments and in familiarizing the librarian with the proper way of reporting statistical findings.

While this approach was useful for developing content for ISfE, the lecture mode of delivery was not scalable by the library across the School as a whole, nor would it be attractive to many faculty who would need to carve out class time for the library lectures. At this stage, Kate Joranson joined the ISfE collaboration and began the process of adjusting the lecture-based material to the online environment as a part of her field placement at the Bevier Engineering Library. The librarians contacted CIDDE for advice in moving the content into a series of online modules that could be incorporated into courses using an online course-management system. Working with Carol Washburn, instructional designer, and Lynn Cooper, production specialist, both from CIDDE, provided an opportunity to synchronize the learning goals with the appearance and navigation of the modules.

It is important that information presented in an online format be visually appealing, promote ease of navigation, and orient the students to the various learning units. The instructional designers suggested that each topic be housed within a folder, headed by the title of that module. Under each title, the learner is also given a brief description of what they can expect to learn prior to opening the folder. This strategy serves two purposes: it allows the learner to feel some control over the material and is an efficient way of setting expectations and stimulating memory recall. As with any publication, it is important to have the organizing strategy transparent to the learner. The organizing strategy within each module includes conversationally-phrased questions followed by short explanations. The questions are highlighted by a colored background as a way of facilitating scanning and locating material should the learner want to find information quickly for review. The questions guide the learner through the modules in a way that emphasizes the relevance of the information. This input from the instructional designers helped the librarians maximize the effectiveness of the instructional content.

The resulting ISfE curriculum consists of 9 modules in a progression of learning, beginning with basic information searching, moving into more complex database searching, evaluation of sources, and ethical use of information. The modules also address the culture of scholarly communication, and the particularities of engineering information sources, such as patents, standards, and technical reports. The modules are text-based rather than image-based so as to facilitate quick implementation and ease of use by various operating systems and software. After reading through the text and sample questions, students finish each module by taking a quiz which measures their conceptual understanding as well as technical ability to complete the sample searches. We cite the NSPE's code of ethics in the module text, building a real-life connection between the students' chosen profession and information literacy standards. Both sets of standards require an understanding of how to use information in ethical decision-making, taking into account authorship, copyright, and the authority of sources. Transferring the information from a lecture format into this online resource enabled the students to learn the skills at their own convenience within the timeframe established by the faculty member.

Developing the instructional modules was an iterative process that involved revision as feedback was received from students. While attitude surveys, quiz results and informal comments served as a measure of effectiveness, a major revision occurred to the content when Thomes, Joranson, and Washburn worked with a small group of engineering students to review the modules. Several students, both 1st year and upper level, participated. The librarian, graduate student, and instructional designer sat with each group of students as they worked, taking notes as the students talked through their thought processes.

Student comments significantly altered the revisions of the modules. They provided invaluable feedback, pointing out sections that were unclear, and making suggestions on how and what to improve. Interestingly, they encouraged us to "make it harder." Quite candidly, they told us that in order to hold the attention of extremely busy, high-achieving students, the modules and quizzes need to carry a weight similar to that of their other projects and tests. We learned that this was not a place to simply lay out the basics; this was a time to really challenge their abilities to think critically, evaluate sources, and perform complex database searches. The older students had a special appreciation for the ISfE modules, wishing they had more courses which gave them a chance to refresh the research skills they had been introduced to in their first year in engineering. Without inviting students into the review process, we would have missed vital information about their actual experience of working with these materials.

The collaboration between all these parties–the engineering faculty, the librarian, the statistician, the graduate student, the instructional designer, the production specialist, and the students--resulted in modules that were aligned in terms of objectives, learning strategies and material, and evaluation.

Conclusion

All these efforts demonstrate the value of collaborations across the whole university. The English Department, the Library, the Office of Instructional Development & Distance Education, and the Office of Measurement and Evaluation of Teaching have all contributed their time and expertise to assisting engineering faculty instruct the whole engineer. Such collaborations allow

engineering faculty to focus on engineering instruction while incorporating professional skills training into their courses in a way that is coherent and smoothly integrated.

Dan Budny defines a whole engineer as one who "sees the whole picture. He or she sees not just the structure, but the entire environment; not just the device, but its ongoing impact on users; not just the process, but the contribution of that process beyond the factory door. In engineering education, we need to make sure students see engineering as part of the whole of life, not just as a set of technical proficiencies."[12] Programs such the Swanson School of Engineering's E/FEWP and ISfE contribute significantly to the "soft" skills that promote whole-picture-whole-engineer vision and action. Such programs cannot exist without contributors from across a whole educational institution valuing and learning from one another's proficiencies, languages, and literacies. To see our work in terms of composition theorist and teacher, Peter Elbow: had we not been willing to articulate our experiences and to hear one another's words, our programs, departments, schools, and we ourselves, would have been "radically impoverished." Instead, through collaboration, we find ourselves and our students enriched by tapping into the multiple intelligences resident within the university as a whole.

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