Communications and Freshman Engineering: An Immiscible Solution?

Lisa Lebduska, David DiBiasio, Worcester Polytechnic Institute

Introducing engineering students to the rewards and responsibilities of being an engineer has long been a goal of engineering education. The Accreditation Board for Engineering and Technology (ABET) specifies that in addition to technical competence, students should have an understanding of professional and ethical responsibility, an ability to communicate effectively, and a knowledge of contemporary issues. At WPI, we attempted to achieve these goals by designing a first-year "mini" (one-credit) course that would actively engage students in the chemical engineering profession while increasing their understanding of speaking and writing as problem-solving tools and means of reflection rather than isolated activities for recording engineered solutions. We used several methods of evaluation to evaluate the success of this course, including focus groups conducted by an external evaluator; an external evaluation of the portfolios, and our own assessment of the students' portfolios.

Background

Most first-year students have little in-depth knowledge of their chosen profession. This is particularly true in engineering since there are few high school experiences connected to the profession. Most chemical engineering departments do not offer core courses until the sophomore year, and hence have little contact with first-year students interested in chemical engineering. Recently more departments are offering seminars or other career-oriented activities for first-year students [1]. Early engagement with the profession can increase motivation for learning and improve retention in the major [2,3]. Improving student understanding of engineering should certainly allow students to make informed, rational decisions about their academic and professional careers. Opportunities are few for fixing this problem, however, and frequently consist of passive activities such as seminars and introductory technical courses. A process that actively and enthusiastically engages students in learning about engineering is needed.

In addition to improving motivation for learning and retention in the major, students' ability to identify with their chosen profession also seems to influence their ability to write effectively. Science writing is often influenced by "a student's inadequate sense of self as scientist"[4] ; a similar rhetorical struggle would be expected for students in engineering disciplines. If engineering students do not view themselves as engineers, they cannot become fully aware of the audience to which they are writing and the specific needs of that audience. Consequently, they approach engineering writing without adequate knowledge of the language practices that define their discipline.

The methodologies used to address this writing dilemma are themselves problematic. Institutions have adopted a range of approaches to improve science students' writing skills, such as Writing Across the Curriculum (WAC) courses that integrate scientific content with rhetorical analysis. Despite their good intentions, however, some of these WAC approaches have nevertheless failed to prepare engineering students adequately for the types of writing tasks that they will encounter academically and in their careers. As scientists and non-scientists often use

different techniques to teach writing, it may be difficult for students to incorporate lessons from the humanities into their engineering coursework [5]. Scientists may also lack the language and understanding of composition studies to teach the writing process effectively. Offering a pedagogical balance between science and rhetoric is thus a challenging problem.

Engineering schools have used various approaches to confront this problem of balance. At Rensselaer Polytechnic Institute, the chemistry department employed writing consultants from the Department of Language, Literature, and Communication to work with junior-level chemistry majors on their lab reports in two required "writing intensive" courses. These consultants met with chemistry faculty to discuss writing practices in that discipline before they began offering feedback to students, who produced multiple drafts of their labs before submitting final versions for grading. The writing focus in this WAC effort targeted upperclassmen and formal lab writing and resulted in better quality lab reports[5]. A WAC effort in the Department of Animal Sciences at the University of Kentucky similarly targeted upperclassmen through a senior-level course, but by contrast it emphasized more "real world" assignments that would help students to recognize the importance of writing in their discipline—an achievement that is often sought by WAC endeavors in engineering and technical programs. The Kentucky course stressed the importance of rhetorical context in writing assignments to improve student interest and clarify assignment objectives[6]. A much broader, more programmatic approach to WAC has been undertaken by the Materials Science and Engineering Department at Virginia Polytechnic Institute, which integrated writing and speaking into eight core courses that students take over a three-year period. The courses in this sequence used a combination of formal and informal ("interpersonal") communication assignments, peer writing consultants, and supplemental writing workshops. Their efforts seem to have contributed to the establishment of a required zero-credit class for majors that requires students to create a writing portfolio containing their best work in a variety of modes from their required classes[7].

Objectives of the WPI Chemical Engineering Course

Because WPI neither offers freshman chemical engineering courses nor requires writing courses, we wanted to design a course that would actively engage students in the profession while improving their approach to and understanding of communication as a problem-solving tool. Students often think of writing and speaking strictly in terms of evaluation, that is the lab report or presentation that they must produce to "prove" that they completed and understood the science. Although first-year chemical engineering majors do not take any chemical engineering courses, they carry one of the heaviest academic course loads on campus, so our challenge was to design a one-credit class that would achieve our pedagogical goals but still attract students.

The Approach

Taught by a chemical engineering professor and a writing professor, the course stressed collaboration between chemical engineering and communication in its design as well as its execution. We reasoned that the best way to teach that communication and chemical engineering should inform each other was to demonstrate the integration, so we collaborated on the design

and delivery of every assignment. We also both attended every class, so that the students would again see the connections between the two disciplines and not think of "writing days" versus "chemical engineering days."

Through a WPI grant (funded through NSF's Institute Wide Reform Program) the first year and a Davis Educational Foundation grant the second year, we offered first-year chemical engineering majors the opportunity to take a tuition-free one-credit course. Course goals were to enhance students' communication skills while introducing them to the working lives of chemical engineers. Nine (out of an original twelve) students submitted complete portfolios in the first year and nine students (out of an original eleven) in the second year.

The Activities

We have offered the course twice (once in Fall 1999, once in Fall 2000), revising the course significantly after the first offering. We required portfolios each time we taught the course, but in the second offering we required the students to submit all of the assignments from the course. Ideally in keeping with writing portfolio pedagogy we would have allowed the students to select what they felt were their strongest pieces, but because we met only once weekly and the course was "low-stakes" (only a single credit) there weren't enough assignments from which to choose. We nevertheless we able to design assignments about chemical engineering that would give the students an awareness of audience; introduce them to group writing, peer response and revision, and give them practice writing reflective cover letters that would initiate a metacognitive approach to writing—that is, get them to think about the process of writing.

Scavenger Hunt

After dividing the class into three groups, we sent them on a scavenger hunt that would introduce them to key resources in communications and chemical engineering: a chemical engineering faculty member; some fancy research equipment (a scanning electron microscope); and the Center for Communication Across the Curriculum, a peer tutoring center for writing and oral presentations. After discussing basic interviewing techniques, we asked the students to interview the faculty member and write an interview for the local AIChE newsletter about him or her. Each group was also asked to give an informal oral presentation about what they discovered during the hunt.

Design Description

We designed this activity so that it would a.) give students experience with accurate, clear description and active listening; and b.) illustrate basic chemical engineering principles and critical thinking skills in chemical engineering. We paired the students, asking them to designate one person "speaker" and the other "listener." We then gave each pair an unlabeled diagram of a basic chemical engineering apparatus. For example, one team had a drawing of membrane separator, while another had a drawing of a heat exchanger. Without looking at his or her partner's paper, the speaker then had to describe the drawing so that the listener could reproduce

it without seeing the original. The students quickly gained an appreciation for precision in description as they realized that they had to give exact measurements and orientations to produce the desired results.

Field Trip

We wanted students to see chemical engineering at work and have the opportunity to ask questions about what they saw. Because we wanted them to experience something fuller than the standard plant tour, DiBiasio contacted engineers he knew personally and arranged for them to spend several hours with our students showing them where and how they worked. To prepare for the trip, we asked the student to read and summarize a professional article related to the research. This exercise gave them practice paraphrasing and summarizing; it also introduced them to the concept of audience. One of the articles, for example, was a business prospectus for a stem cell biotechnology firm and we asked the students to extract information that a cancer patient with no scientific background would need.

Each group was required to write an article for the school newspaper that incorporated the background material from what they had read with what they had observed and learned during the field trip.

Distillation Tower

This activity was designed to introduce the students to a basic piece of chemical engineering lab equipment, the basic chemical engineering principles involved in the operation of that equipment, and to give them practice articulating those principles. We visited the Unit Operations Lab for a tour and demonstration of a working distillation column. The column is constructed entirely out of glass so all operations can be easily observed. For all students, this was the first time they actually observed the operation of a large-scale piece of chemical processing equipment. Prior to the visit students were asked to develop and sketch a strategy for producing nearly pure ethanol from a fermentation broth. After the visit they had to produce their own sketch of the column, including the working internals, and write a description of the entire process. Additional calculations were required that answered questions concerning the total amount of ethanol that might be needed to power all cars in the city of Worcester on gasohol for a year.

Ethics

Using the Online Ethics Center web site (http://www.onlineethics.org/) we designed an assignment to introduce students to common chemical engineering ethical dilemmas. We used the case study on "Request to Falsify Data" to generate in-class discussion about how the engineer in the case study might have responded to being forced to falsify data by her boss. The data concerned an environmental spill. The writing assignment followed up on this discussion by asking students to evaluate the problem from several other perspectives such as a member of the state's environmental protection agency, the CEO of the company, company attorneys, and members of the community.

MQP (senior thesis)

For this activity we wanted the students to listen to and ask questions of their older peers who were much closer to being working chemical engineers but were still students. We therefore invited two teams of students who were in the middle of researching their Major Qualifying Projects (MQP's), which are senior theses. Two teams presented their research to the class, and, at our behest, talked about the role communication played in conducting and presenting their research.

Evaluation

An external evaluator administered surveys and conducted focus groups with students who had enrolled in the course and concluded that the project had succeeded in producing gains in student knowledge of the activities in which chemical engineers engage. One of the greatest struggles for the students involved the group writing assignments, which they found difficult to complete because of incompatible schedules. Some also felt that the course required too much writing for a single-credit course. In the second iteration of the course we addressed the group logistics problem by giving them more instruction in collaborative writing, fewer collaborative writing assignments and more in-class time to write collaboratively. We did not decrease the frequency of writing assignments, however, as we felt that they were crucial to achieving our objectives.

The external evaluator of the portfolios concluded that the course contributed to student learning. The evaluator noted that although the students' portfolio cover letters did reflect on their learning, they did not demonstrate an understanding of how the course's various assignments were related. We attempted to address this deficiency by giving clearer letter-writing guidelines in the second iteration of the course.

Perhaps the greatest insights about the course came from the students themselves. Most of the students recognized the marketability of the skills the course provided. One student, for example, wrote the following:

"Unless an engineer is involved in solitary research and development, he or she cannot expect to survive in the job market without superior communication skills. These skills are needed to get hired via an interview, to coherently and precisely express problems to the brass of the company, and to write technical reports that management can read without first acquiring an engineering degree."

Regarding the Design Description activity, one student wrote:

"It was fun and gave me a very interesting idea that no matter how intelligent a Chemical Engineer could be, it would not do any good if he/she could not communicate with others in an understandable way. Even though it was just a sketch of a simple mechanism, I still could not determine the correct orientation given by my partner. We ended up having a very funny looking heating chamber…….After the first class, I began to understand why communication was also very important for a good Chemical Engineer."

Regarding distillation and the course:

"A distillation column takes a mixed solution and purifies it until you have an almost pure substance. It does this through many small steps, getting more pure as the substance goes along. I feel that my writing skills, communication skills, and my knowledge of the major of chemical engineering have taken similar steps. They started very rough, from the first assignment of the drawing, to the final, almost pure piece, this cover letter."

On the course in general:

"The chemical engineering/communications course defined what chemical engineering is and how important communication is to any career…….. Chemical engineers question the durability of a structure that houses chemicals, the procedures involved in a reaction, and how efficient the procedure is. They ask questions such as is the maximum product being produced using this amount of energy and if not how can it be? Will this structure support the operation and withstand outside forces to prevent a chemical leak? All these questions offer a challenge to the chemical engineer to try to improve the current operations. After all, that is what chemical engineers do, solve problems and improve the reactions going on around them."

And finally:

"What did I learn from this course? Well, I was exposed to environmental conservation organizations and I saw equipment used at the industrial level being implemented to be environmentally friendly. ……..I was subjected to morally stimulating situations which made me think, which is novel and frightening. And finally I was presented two projects that would be assigned to everyday chemical engineer. In my opinion I feel that I have learned something about the chem. eng. profession and that I must remember to communicate my ideas to others succinctly and clearly as I take the roller coaster ride of education towards the tunnel of real life working environments."

Conclusions

Despite problems such as course logistics, students time constraints, and resistance to writing, most students demonstrated growth in their knowledge of the profession and their use of communication as a learning tool. Additionally, we discovered that collaboration between seemingly unrelated disciplines aids in faculty development (an opportunity to see how the other half thinks) but to be truly effective this approach needs to be transported beyond the two faculty members involved to a more globalized WAC (Writing Across the Curriculum) endeavor.

Bibliography

[1]Roberts, S.C., "A Successful Introduction to Chemical Engineering First-Semester Course Focusing on Connection, Communication, and Preparation", proceedings of 2000 Annual Meeting of AIChE, Los Angeles, *Chemical Engineering in the New Millenium*, 406-411.

[2]Young, V.L. (2000) "Technical Communication and Awareness of Social Issues for Sophomores", proceedings of 2000 Annual Meeting of AIChE, Los Angeles, *Chemical Engineering in the New Millenium*, 399-405.

[3]Yokomoto, C.F., M. Rizkalla, C. O'Laughlin, M. El-Sharkawy, and N. Lamm, "Developing a Motivational Freshman Course in Using the Principle of Attached Learning", *Jour. Eng. Ed*., 88:2:99-105.

[4]Balley, R. and C. Gelsler. (1991) "An Approach to Improving Communication Skills in a Laboratory Setting." *Journal of Chemical Education,* 68:2:150-152.

[5]Lablanca, D. A. (1985) "Writing Across the Curriculum: A Heretical Perspective." *Journal of Chemical Education,* 62:5:400-401.

[6]Aaron, D. K. (1996) "Writing Across the Curriculum: Putting Theory into Practice in Animal Science Courses." *Journal of Animal Science* 74:11:2810-2827.

[7]Hendricks, R. W. and E. C. Pappas. (1996) "Advanced Engineering Education: An Integrated Writing and Communication Program for Materials Engineers." *Journal of Engineering Education,* 85:4:343-352.

LISA LEBDUSKA is Director of the Center for Communication Across the Curriculum and an adjunct assistant professor of writing at WPI. She received her PhD in English from the University of Rhode Island. Her most recent article, "Peer Writing Tutors," will be appear in *Student-Assisted Teaching* by Anker Publishing, and reflects her research in peer tutor training, writing in the disciplines, and technologies of writing.

DAVID DIBIASIO is Associate Professor of Chemical Engineering and assessment coordinator for the Interdisciplinary and Global Studies Division at WPI. He received his PhD in chemical engineering from Purdue University and has worked for the DuPont Company. His educational work focuses on educational assessment, active and cooperative learning, writing and chemical engineering, and international engineering education.