

**AC 2003-1237: TEACHING STRATEGIES FOR INTEGRATING
COMMUNICATION IN THE CHEMICAL ENGINEERING LAB**

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Abstract

This paper discusses strategies for teaching communication in the senior chemical engineering laboratory course, ChE 229w, at Vanderbilt University Engineering School. Specifically, the author reports on teaching techniques, in-class and online assignments, and evaluation methods to enhance integrating communication and technical instruction in the lab.

Introduction

In the last few years, papers at engineering education conferences and journal articles have explored rationale and methods for integrating communication and engineering instruction.¹⁻⁴ The Chemical Engineering Department at Vanderbilt has been integrating this type of instruction for the past 22 years in both the junior and senior chemical engineering labs. Even before ABET required constituent feedback, the professors teaching the junior lab surveyed our recent graduates with an average of three years in the field to learn and incorporate their recommended improvements.⁵ The team-teaching of a chemical engineering professor and a technical communication professor in these courses has received praise from both ABET and alumni. The preparation for communication tasks offered by the department has also received high ratings in graduating senior surveys.⁶

The junior lab, ChE 228w, deals with transport phenomena and the basic principles of momentum, heat, and mass transfer. The senior lab, ChE 229w, focuses on separations studies and has pilot plant-size absorption, extraction, and distillation columns. In addition, several experiments include chemical reactor design and operation.⁷

Technical writing instruction has been integrated into the junior and senior chemical engineering labs since 1981. Since 1982, I have been the department's technical communication professor, designing and teaching the technical communication portion of both labs in addition to teaching a technical communication course for all engineering majors. The designation "w" after the course number for each laboratory course, ChE 228w and ChE 229w, indicates that these courses include writing instruction. Beginning in 1987, however, students in these junior and senior labs have received training in both written and oral communication.⁸

In each course, students write numerous reports and give two videotaped oral presentations with visuals. The chemical engineering professor grades the technical content. The technical communication professor grades the organization, delivery, and visual aids in oral presentations and grades the report format, organization of ideas, grammar, and punctuation in written reports.

Changes have been made in the strategies for teaching technical communication in both courses. The technical communication aspect of these labs has progressed from writing instruction only to instruction in both written and oral communication, teaching teamwork, and using alternative methods of course delivery. I have also added technical communication sections to the lab manuals (ClassPaks) for each course and continue to revise these.⁹

The 1992 survey results from our chemical engineering graduates with an average of three years' experience in the field caused changes in technical communication assignments for both labs. These alumni reported that about 50 percent of their time was spent on written and oral communication tasks at work. They made two major recommendations: increase oral presentations and include a variety of short reports like those in industry.¹⁰ Feedback from newly added surveys of recent graduates for the last three years indicates that they feel prepared for communication tasks in the workplace.¹¹

This past year since I was teaching for the first time with the same chemical engineering professor for both labs, we had the opportunity to redesign this two-course sequence. Consequently, I made some extensive changes for the technical communication segment for both courses, but particularly in the senior lab. This paper details some successful strategies for teaching communication in the senior chemical engineering laboratory, ChE 229w. Specifically, I report on in-class and online activities to enhance integrating technical communication and technical instruction in the lab, helpful forms for evaluating written and oral reports, and an instrument for student assessment of course results. For those strategies already described in other papers, I briefly summarize them and cite the sources containing more information. For strategies just recently added, I provide more details.

Objectives of the Technical Communication Segment

Before Fall 2002, the purpose of the senior lab was to provide students with training in various types of written and oral lab reports and to apply Kolb learning style theory to teamwork interaction. This course is now designed to give students additional instruction and practice in job search communication and to acquaint them with various forms of current communication tasks in the workforce. By the end of this course, students should be able to meet the following objectives:

1. Analyze and target a dual audience (technical and non-technical) in both written and oral communication
2. Recognize and follow good technical communication principles of organization, development, formatting, and simple, clear, direct language in various writing assignments
3. Give two oral presentations with attention to organization and development, delivery, and visual aids
4. Write an organized short lab report in assigned format
5. Write several memo lab reports
6. Write a memo analysis of team interaction based on Kolb learning style theory
7. Edit and simplify wordy passages

8. Create PowerPoint visuals using techniques for visual reinforcement of ideas
9. Work in teams to write a report and give an oral presentation
10. Discuss various kinds of written and oral communication tasks required of ChE majors at work
11. Create a resume with power verb phrases describing accomplishments rather than just duties
12. Analyze accomplishments using industry job requirements as criteria
13. Analyze past experiences to create effective answers to interview questions
14. Demonstrate effective techniques in answering interview questions, using the particular method presented in class

Strategies for Course Delivery

The revised ChE 229w course has changed somewhat the method of course delivery for technical communication. In addition to the regular five-hour lab and one-hour class meeting per week for technical communication lectures and classroom activities, course delivery includes Web courseware, e-mail, individual conferences, and alumni guest speakers.

Usually both professors are present during the one-hour class although the class is usually devoted to communication. Occasionally, both professors share the hour when the chemical engineering professor needs more time to explain technical issues. Sometimes both professors comment on report writing requirements and critique sample reports.

Over the past few years, like other engineering educators who have expanded their teaching techniques to include the latest advances in technological tools,¹²⁻¹⁷ I have added online capabilities for course delivery. To supplement class meetings, I now use e-mail and the Web as teaching tools.

E-mail. Teaching with e-mail expands the teaching function and creates rapport between the instructor and students. I send messages both to individual students and to the entire class as needed. As I have mentioned in a previous article, sending e-mail to an entire class can be used to give tips for an upcoming assignment, add information omitted in class, answer potential questions that may arise when students are doing homework, and alert students to problems students have had in the past.¹⁸

The maximum number of messages sent to the entire class usually is about one e-mail message a week. Of course, I answer individual messages every weekday and usually on Sunday night, but these average less than six per day.¹⁹ I avoid sending too many e-mail messages so as not to overload students' mailboxes and diminish effectiveness.²⁰

Prometheus Web Courseware. In addition to e-mail, I use Prometheus Web courseware as a supplement, posting files such as report examples, tips for completing assignments successfully, PowerPoint lectures, syllabus, course description, and assignments. The Messages section automatically adds e-mail addresses of all students enrolled in the course, so I can easily send individual or group messages to students from within Prometheus.

Recently, following student suggestions, I have relied more on Prometheus to post lecture material, including Word files and PowerPoint slides with illustrations, some with recorded voice narration. Students also use Prometheus to post files and give peer reviews of papers. In addition, instead of having students buy a printed copy of my portion of the course manual (ClassPak), I posted it online.²¹

Prometheus courseware has proved useful in offering online capabilities to supplement traditional delivery of the course. Students appreciate the fact that they can access a lecture and pertinent materials online at any time. The one problem my ChE students have had with Prometheus is downloading from off-campus computers a large file containing a voice-narrated lecture, so I have learned to use voice narration sparingly. Otherwise, Prometheus has been helpful, particularly for providing access to urgent information or for peer reviewing papers between classes.²²

Alternative Use of Class Time. Beginning in the 2002 fall semester, my posting online more lectures and class activities (such as peer review) than in the past has allowed time to add new class activities. Two of these are discussed in the next section: alumni guest speakers talking about their communication tasks at work and job search communication assignments.²³

Freeing up class time also allowed more time for instruction through individual conferences. I, therefore, increased required and optional individual conferences with students, sometimes during regular class times. I used the conferences to discuss both ungraded and graded written assignments and to evaluate students' answers to an impromptu interview question.

Strategy for Bridging the Workplace/Classroom Gap: Alumni Guest Speakers

The biggest and most positive change I made in ChE 229w was bringing alumni guest speakers to bridge the gap between the workplace and the classroom. I requested that they each speak for an hour about communication tasks in their jobs. In the past, I had invited one or two guest speakers to my other classes to speak on various communication topics. Including numerous speakers as part of a course, however, and particularly a combined chemical engineering lab/technical communication course, was a big gamble in my opinion. I kept asking myself these questions: What if speakers do not want to come? What if the presentations do not go well? What if their talks are not relevant or valued by the students?

I need not have worried. My researching, hand picking, contacting, and scheduling prospective alumni speakers and facilitating their presentations resulted in unexpected benefits. Surprisingly, speakers were quite willing to volunteer their time and travel expense and seemed pleased to be invited. The result was five excellent guest speakers from various companies and cities, all Vanderbilt chemical engineering alumni, speaking about communication tasks required in their jobs. They also briefly described their work experience. The effort they devoted to preparing their talks was obvious. All gave specific examples of different types of writing and speaking tasks. Some even brought in examples as handouts. Students appreciated hearing, not just from their technical communication instructor, but from chemical engineering graduates about the importance of communication skills in the workplace. Besides learning from the content of the

talks, students benefited from observing the speakers model good presentation skills. Although not my reason for inviting the speakers, at least one student got a strong job lead. In addition, these guest speakers not only helped bridge the gap between work and school and captured students' attention; they also spiked my enthusiasm for my job. One even thanked me in front of the class for teaching him valuable skills that he now uses in his job everyday.²⁴

The speakers represented various types of communication tasks, companies, locations, work experience, and even age groups. This variety illustrated the broad spectrum of possible communication and work experiences that chemical engineering majors may anticipate after graduation. Types of jobs represented ranged from expected chemical engineering tasks to sales, management, and consulting. The speakers represented employers such as NASA, Magotteau, Gobbell Hays Partners, and DuPont. Only two speakers worked in Nashville, where Vanderbilt is located. Of the remaining three, one was from Delaware, one from Alabama, and one from Texas. Three different decades were represented, with one speaker having graduated in the '70's, two in the '80's, and two in the '90's. In addition to all speakers being alumni, four of the five were my former students. (A sixth speaker, a 2002 graduate from Marathon Oil in Illinois, accepted but had to cancel travel plans because of extreme weather conditions.)²⁵

Students really enjoyed the presentations and gave positive feedback, some unsolicited. When asked on the course evaluation form whether this aspect of the course should be continued next year, the overwhelming majority highly recommended that it should. This recommendation received the highest rating of any of the 16 questions on the form, a 4.4 on a scale of 1 to 5.

Strategies for In-Class Activities and Assignments

The in-class learning activities for technical communication in ChE 229w are designed to prepare students to write and present several types of lab reports, to work together in teams, and, most recently, to use communication skills to get a job.

Group Analysis of Report Transparencies. One of the most effective strategies I have ever used is assigning a report for in-class analysis. Each group of three (or occasionally four) students gets a transparency of an old report, a water-based transparency pen, and 20 minutes to analyze the report using established criteria. Criteria deal with report format, paragraph development, handling of figures and tables, and reference citations. Any wordiness and grammar problems noticed can also be discussed. Then each group's designated speaker puts the transparency on the overhead and presents the critique. In this way, other students and I can comment on their assessment and point out any problems or weaknesses missed. It is also a good way for me to see where students misunderstand report writing requirements.

Rewriting Reports. Allowing students to rewrite one or two graded papers provides a good way to reinforce writing skills. This assignment ensures that students review the instructor's grading symbols and comments on their errors instead of merely looking at the grade and then making the same mistakes on the next paper. Based on how well they correct their errors and improve the report, I assign up to half their missed points back on the original paper. However, students must turn in the original with the rewritten version to receive credit for revision.

Self Evaluation of Videotaped Reports. Requiring students to evaluate their videotaped speeches is an effective teaching method. The videotape provides a good means for the instructor to give individual instruction in a student conference. My students use a checklist for evaluating aspects of organization and content, delivery techniques, and visual aids. They rate themselves and turn in the checklists, which count ten points. In my view, seeing themselves on tape is one of the most helpful tools for correcting mistakes, even more than the instructor's comments.²⁶

Peer Evaluation of Oral Presentations. In addition to the instructor's grade sheet given to students immediately following their presentations, their peers also evaluate the presentations in class. Using a checklist to rate presentation skills and write comments, students evaluate the speakers and give them the checklists. It is gratifying to see speakers pore over these and even more gratifying when peer evaluators make the same comments as the instructor.

Teamwork Training with the Kolb Learning Style Inventory. Working in teams in the engineering classroom and laboratory is a topic explored in engineering education papers, especially in the last ten years.²⁷ One activity I have used for years is teamwork training with the Kolb Learning Style Inventory (LSI). Teaching students how learning styles affect team interaction and even leadership styles can help students improve their team's performance in the lab and in group reports, both written and oral.²⁸

Through lecture and interactive exercises, I train students in applying Kolb theory to group interaction. Using my explanatory handout, they practice analyzing the effect of learning styles on teamwork, leadership styles, and conflict resolution. After taking the test and participating in two class sessions, students are required to keep a log of their group's interactions. At the end of the semester, they interpret these according to the group members' learning styles in a memo report. They discuss all members of their group, including themselves, and analyze how the group achieved consensus, performed tasks, and resolved conflicts. A more detailed description of this learning style segment has been reported in other publications.²⁹⁻³¹

Job Search Communication Assignments. New assignments in ChE 229w are aimed toward preparing seniors for the job search. Since they take this course in the fall semester, it is an ideal time for them to use what they learn. I included the following activities and assignments in job search communication:

1. a resume chart analyzing the student's strengths and weaknesses based on researching ten jobs
2. peer review of the resume draft
3. individual conference with the instructor about the resume
4. an in-class workshop on a method for answering behavioral interview questions
5. an interview chart analyzing the students' past experiences for use in interview responses
6. a response to an impromptu interview question in an individual conference

After drafting a resume based on the resume chart, students post the resume draft on Prometheus for peer review from two other students. Students also have an individual conference with me

about their resume and then revise it for a grade. Using methods learned in the interview workshop, they use their interview chart to prepare for almost any type of behavioral question. The method focuses on describing past actions leading to positive results in their experience.

Strategies for Evaluation

In evaluating written and oral reports, I use two grading forms, one adapted from other instructors and one I designed. In addition, for student responses about improving the course and assessing their learning, I designed an evaluation form based on the instructional objectives.

Evaluating Written Reports. My grading sheet for written reports uses an analytical, numerical scale to evaluate five categories of writing (Table 1). The categories are given numerical weights, starting with the largest values and ending with the smallest. I adapted the form, based on the Diederich scale,³² created by several Vanderbilt professors who evaluated the first year of our ChE technical communication program.³³ When the course begins, I present and discuss a handout for students explaining each category. Since the chemical engineering professor is grading for technical content, the category Organization and Development refers to format, paragraph structure, correct placement of information in the required report sections, handling of tables and figures, and reference citations.

Table 1. Grading Sheet for Technical Writing in the Vanderbilt ChE Labs

Grading Sheet for Technical Writing							
1. Organization and Development	1	2	3	4	5	(x 6)	30
2. Coherence and Sentence Structure	1	2	3	4	5	(x 6)	30
3. Usage and Vocabulary	1	2	3	4	5	(x 4)	20
4. Punctuation, Capitalization, and Spelling	1	2	3	4	5	(x 2)	10
5. Neatness, Readability, Visual Impact	1	2	3	4	5	(x 2)	10
Comments:							100

Evaluating Oral Presentations. Influenced by the technical writing form, I recently have designed a similar evaluation form for oral presentations (Table 2). This replaced the detailed, less quantitative oral presentation form that I had previously used, designed for another course by former Vanderbilt professors. My new form is more useful for in-class grading of group-presented lab reports. Because I do not evaluate the technical content of the presentations, the Organization and Development category does not get as much weight as Delivery. I am still

experimenting with appropriateness of numerical weights. For documentation errors, I subtract points.

Table 2. Grading Sheet for Oral Reports in the Vanderbilt ChE Labs

Grading Sheet for ChE Oral Presentations							
1. Organization and Development (Communication aspects only: intro; overview, sound plan; easy to follow; clear; definitions; transitions; conclusion; tailored to audience)	1	2	3	4	5	(x 4)	20
2. Delivery (Stance; eye contact; gestures; freedom from notes; appropriate language; voice qualities, tone, volume, variance; poise, confidence; rapport with audience; emphasis)	1	2	3	4	5	(x 11)	55
3. Visual Aids (Readable, appealing; concise; appropriate; consistent fonts, colors; appropriate illustrations; handled well)	1	2	3	4	5	(x 5)	25
5. Documentation (Rating given; points subtracted for incorrect or missing citations)	1	2	3	4	5	(x 2)	- 10
Comments:							100

Evaluating the Course. In addition to the official course rating sheet required by the Engineering School, I developed a self assessment form based on the course objectives for students to evaluate their proficiencies in technical communication before and after ChE 229w (Table 3). When students wait until the end of the course to assess their technical communication proficiencies upon entering the course, they are less likely to inadvertently inflate their original knowledge. I have found this form quite helpful in providing responses about student learning. Since its inception two years ago, most students have rated themselves as greatly improved after taking the course.

Table 3. Student Self Assessment of Technical Communication Proficiencies Gained from ChE 229w

ChE 229w Self Assessment of Technical Communication Segment Results		
Rate your knowledge and/or experience with each of the following items both before and after taking ChE 229w. Answer the following questions on a scale of 1 to 5 with 1 being the lowest and 5 being the highest rating. Place the number beside the item in the appropriate column. Then answer the following questions to help us plan for next year.		
Proficiencies	Before ChE 229w 1 2 3 4 5	After ChE 229w 1 2 3 4 5
1. Knowledge of/ability to follow good technical communication principles (organization; development; formatting; simple, clear, direct language)		
2. Knowledge of/ability to give good oral presentations		
3. Knowledge of/ability to write an organized lab report		
4. Knowledge of/ability to analyze and target the audience		
5. Knowledge of/ability to write effective memos		
6. Knowledge of/ability to write simple, clear, direct language		
7. Knowledge of/ability to edit and simplify wordy passages		
8. Knowledge of/ability to create effective visuals		
9. Knowledge of the types of jobs that ChE majors may have		
10. Knowledge of various kinds of written and oral communication tasks at work for ChE majors		
11. Knowledge of/ability to create a resume with power verb phrases describing accomplishments, not just duties		
12. Knowledge of/expertise in effective interviewing techniques, particularly the method presented in class		
Comments:		

For this year's class, I added questions to the standard 12 listed above to learn student recommendations about changes in the course.

Conclusion

The technical communication portion of the ChE 229w course has progressed from writing instruction only to instruction in both written and oral communication, teaching teamwork with Kolb learning style theory, online supplemental instruction, and, just recently, job search communication and bringing the real world into the classroom through a series of alumni guest speakers. Along the way, I have added the strategies discussed for course delivery, teaching, assignments, and evaluation. The chemical engineering professor and I are now planning to require short e-mail "blurb" updates with brief text explanations and tables of data as described by

one guest speaker. We are also exploring ways to use the engineering method in teaching students how to plan an experiment.

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