ChE classroom

DEVELOPMENT OF ORAL AND WRITTEN COMMUNICATION SKILLS

Across An Integrated Laboratory Sequence

JAMES A. NEWELL, DOUGLAS K. LUDLOW, AND STEVEN P.K. STERNBERG
University of North Dakota • Grand Forks, ND 58202-7101

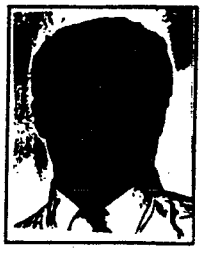
There can be little doubt that the development of effective oral and written communication skills is an essential component of an engineer's undergraduate education. Regrettably, strong communication skills remain the exception rather than the rule for many engineering graduates.[1] Kranzber[2] reported that, for engineers who had been out of school for ten years, the most common answer to the question "What courses do you wish you had taken?" was English and/or writing courses.

The Canadian Accreditation Board has even included a statement requiring that students' communication capabilities be developed.[3] Fortunately, many engineering programs now focus on the developing the entire engineering student by incorporating the concept of writing-to-learn in their curricula.[4-6]

Despite this growing consensus, there remains little agreement on how best to approach the cultivation of these skills. Some argue that humanities electives are the appropriate forum for addressing these concerns, but Stevenson[7] observes that as an engineering student's perception of a course's connection to engineering decreases, the amount of time spent on that course also tends to decrease. Thus, by failing to connect the importance of written and oral presentations to engineering careers, we are undermining the perceived value of these skills, despite the fact that most engineers will find themselves writing memos, reports, or articles throughout their careers.[8] Thus, it is essential that the importance of writing and oral presentations be related to the core engineering principles that the students value.

A movement to integrate writing across the curriculum has been undertaken at many universities, including the University of North Dakota.[4] Clearly, this is a departure from the classical view of many engineering lecturers who would claim that they are too busy teaching engineering to teach writing. The ability to formulate a coherent written report, however, requires that the student think clearly about the engineering problem.[9,10] Although these programs represent a distinct step forward, they do not address the problem of how to incorporate the development of communication

James A. Newell *became an assistant professor at the University of North Dakota in 1995 after spending one year at Clemson University as a visiting assistant professor. His research focuses on high-performance polymers and composite materials. He is a member of the American Carbon Society, AIChE, and serves as a board member of the New Engineering Educators Division of ASEE.*



Steven P. K. Sternberg *received his PhD from Purdue University in 1994. He was an assistant professor at the University of Detroit Mercy before going to the University of North Dakota in 1995. His interests include groundwater transport modeling, metal removal from waste water, and environmental outreach.*

Douglas K. Ludlow *served as the chair of the chemical engineering department at the University of North Dakota from 1994 to 1996. He recently left UND to become the chair of the chemical engineering department at the University of Missouri-Rolla. His research focuses on surface characterization and fractal analysis of chemical phenomena.*

. . . it is essential that the importance of writing and oral presentations be related to the core engineering principles that the students value. . . . The University of North Dakota uses a four-semester, four-course laboratory sequence [to develop these skills]. Each class is designed to build upon the technical and writing concepts and skills developed in the previous class. Care is taken, however, to ensure that these skills enhance rather than replace the important technical skills developed in the lab.

skills into the curriculum. At the University of North Dakota, we have developed an integrated laboratory sequence to systematically enhance the communication skills of our students.

PROGRAM

The University of North Dakota uses a four-semester, four-course laboratory sequence. Each class is designed to build upon the technical and writing concepts and skills developed in the previous class. Care is taken, however, to ensure that these skills enhance rather than replace the important technical skills developed in the lab. The lab instructors stay in regular communication and coordinate group selection and writing assignments. Additionally, the department has hired a quarter-time writing consultant to aid in evaluating the reports. The consultant is an engineer with industrial experience in evaluating technical reports. She assists in Labs II through IV. The individual lab classes are described in the following paragraphs.

Lab I

The first lab, taken during the second semester of the second year, focuses on the fundamentals of laboratory measurements and writing. Students work in three-person groups and submit individual reports. The ten reports in Lab I consist of one-page summary memos to the instructor. This introductory lab class forces students to selectively reduce an entire experiment's worth of information down to only one page of relevant text. Writing assignments are frequent and the feedback is rapid. There are no oral presentations required in this lab.

Lab II

The second lab class focuses on the chemical and physical properties of materials and is taken in the first semester of the third year. Again, the students work in three-person groups, but the nature of the reports changes dramatically. The student groups write a single-group memo for each experiment, similar to the individual reports in Lab I, but this time the memo is returned to the students with detailed feedback. The students then return to the lab and acquire additional data, and each group member is required to submit a final report in one of the following formats: Technical Journal, Operations Manual, Oral Presentation, or Peer Review (all described in the following paragraphs). As a consequence of the expanded format, each group runs fewer experiments than it did in Lab I. Each group runs a total of four experiments and spends four three-hour lab classes acquiring data for each experiment.

Technical Journal • The technical journal article is the standard for engineering research. Each student is expected to produce a report that includes an abstract, an introduction, an experimental-methods section, a theoretical development, the results and discussion, the conclusions, the recommendations, and references. The student must examine outside sources to write a coherent introduction and must fully understand the experiment to write a reasonable results-and-discussion section. The students is required to submit three copies of the report; one is graded by the faculty instructor, one by the writing consultant, and the third is given to another student for peer review.

All three copies of the report and associated critiques are returned to the student. The grade is determined by a weighted average of the writing consultant and the faculty instructor's grade (the student peer review does not impact grading). The student is required to revise the report based on the three reviews and to resubmit a final draft of the technical journal at the end of the semester. The final draft is graded by the writing consultant and the instructor and is worth twice the number of points as the earlier draft.

Operations Manual • One member of each group is required to develop a detailed operations manual. He or she is told that the company sells experiments to high school chemistry classes. The student must develop an instructional packet that will enable high school students to perform the experiments with minimal supervision. The packet must also address data analysis and include complete sample calculations. The students must also generate a cover letter, thanking the high school instructor for purchasing the product and explaining the proper use of the manual. This report forces students to address a less sophisticated audience than did the technical journal.

Oral Presentations • One member of each group is required to give a twenty-minute oral presentation based on his or her experiment. The student is provided a sample "audience" to which the presentation should be targeted. These audiences include scientists at a technical conference,

a group of marketing executives, or a room full of high school students. The student is expected to present material at a level commensurate with the target audience. The grade for the oral presentation is weighted as equivalent to one written report. Students are graded by the Lab II instructor, the writing consultant, and the Lab III instructor, although all students fill out an evaluation form (shown in Figure 1).

The different oral presentations are scheduled at different times throughout the semester, and all students are required to attend every presentation. Invariably, the students who present later in the semester make fewer mechanical or lack-of-preparation errors. They have learned from watching and evaluating the previous speakers. Therefore, each report type is graded independently to minimize the disadvantage to students who presented early in the semester.

Peer Review • During the course of the semester, each student is given a copy of another student's technical journal. The reviewing student is expected to perform a detailed review of the paper, identifying both strengths and weaknesses, making recommendations for revision, and identifying additional data requirements. Although the student review does not affect the grade of the student who wrote the journal article, the review itself is graded as a lab report. By requiring students to perform a formal review of another student's work, the students are forced to consider what elements lead to an effective technical journal. Additionally, the extra review provides more feedback to the student author of the original paper, which facilitates the revision process.

Lab III

The students continue to measure chemical and physical properties and are exposed to unit operations in the third lab, taken during the second semester of the third year. Students work in groups of three, but each of them submits an individual report and each is assigned a different type of report. Experiments are performed in two distinct halves. The first half follows a standard written procedure, while the second half requires the group to design and implement changes the original experiment that either improve the precision/accuracy or explore an interesting sub-part of the original experiment. The goal is to provide students with a taste of how research can be conducted, as well as to give students an opportunity for critical thought. The three groups of reports include 1) poster presentation (which includes a written abstract) and an oral presentation, 2) a memo-to-file and a technical paper, and 3) a memo-to-customer and an operation manual. Because a report is due from each half of the experiment, the students write a total of six reports on three experiments.

Oral Presentation Evaluation Form

Evaluator _____ Speaker _____

Date _____

Unacceptable: 1	Marginal: 2	Fair: 3	Good: 4	Excellent: 5

Organization (overview of presentation, summary, flow, use of time, etc.)

_____

_____

Poise and Appearance (appropriate dress, fidgeting, nervousness, etc

_____

_____

Delivery (eye contact, voice, rate of delivery, etc.)

_____

_____

Overheads and Aids (neatness, font size, titles and labels, use of space, etc.)

_____

_____

Content (level of information, adequate discussion and analysis, summary, etc.)

_____

_____

Questioning (poise, interaction with audience, overall answer)

_____

_____

Overall effectiveness (did the speaker chieve his or her objectives?)

_____

_____

Total Score (35) _____

Figure 1. Oral Presentation Evaluation Form

The report styles are very similar to those described in the Lab II section, with the exception of the memo formats. For these memos, the students create short (four-page) descriptions of their work and its results. They also must discuss at least one concrete improvement that can realistically be implemented that will improve or expand on the results obtained. This improvement is the basis for the second part of the laboratory. All written reports must also include the following appendices: information on chemical hazards, proper environmental precautions (especially waste disposal), and human safety (*e.g.*, proper operation of equipment).

Lab IV

The final lab in the sequence is taken during the first semester of the fourth year. It focuses on unit operations, process control, and optimization. Again, three-member groups are used, but all submissions are group reports. The technical journal and oral presentations exist as in Labs II and III, but are written or presented by the entire group. In addition to these report formats, the students are required to submit a memo-to-file, a report to their supervisor, and a letter home to their non-technically oriented parents. Again, the goal is to provide students with the opportunity to write about technical information in a variety of styles for a variety of audiences.

SUMMARY

In today's competitive world. solid communication skills are increasingly essential for engineers. At the University of North Dakota, an integrated laboratory sequence is used to progressively develop these skills as well as the technical skills required by undergraduate engineering students. By systematically building on writing and speaking skills, the labs provide students with a means for improving their communication abilities.

REFERENCES

1. Bakos, J.D., "A Departmental Policy for Developing Communications Skills of Undergraduate Engineers," *J. of Eng. Ed.*, p. 101, (November 1986)
2. Kranzber, M., "Educating the Whole Engineer," *ASEE Prism*, P. 28 (Nov. 1993)
3. Canadian Accreditation Board, 1993 Annual Report, Canadian Council of Professional Engineers (1993)
4. Ludlow, D.K., and K.H. Schulz, "Writing Across the Chemical Engineering Curriculum at the University of North Dakota," *J. of Eng. Ed.*, 83(2), p. 161 (1994)
5. Aris, R. *Chemical Engineering and The Liberal Arts Today*, The School of Chemical Engineering, Oklahoma State University, Stillwater, OK (1991)
6. Kreiger, J., "Push to Restructure Precollege Science Education Gets More Emphasis," *Chem. and Eng. News*, 25(2), p. 96 (1991)
7. Stevenson, S., "Integrating Complementary Studies in the Engineering Curriculum: A Role for Communication Skills Programs," *1994 ASEE Ann. Conf. Proc.*, Edmonton, Alberta, Canada, p. 2340 (1996)
8. Paradis, J., D. Dobrin, and R. Miller, "Writing at Exxon ITD: Notes on the Writing Environment of an R&D Organization," in *Writing in Non-Academic Settings*, L. Odell and D. Guswami, eds., Guilford Press, New York, NY, p. 281 (1985)
9. Elbow, P., "Teaching Thinking by Teaching Writing," *Phi Delta Kappan*, p. 37 (1983)
10. Van Orden, N., "Is Writing an Effective Way to Learn Chemical Concepts?" *J. of Chem. Ed.*, 67(7), p. 583 (1990) ❐