# TEACHING TECHNICAL COMMUNICATIONS WITHIN A FRESHMAN ENGINEERING COURSE SEQUENCE

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## ABSTRACT

A significant technical communications component has been included in a newly designed Freshman engineering sequence. This three-quarter series is intended to introduce students to the profession of engineering and to provide skills and tools needed for success in upper-level courses and professional practice. Included in the sequence are various aspects of technical communications, including written documents, graphs and drawings, and oral presentations. This paper will present some of the methods used to integrate technical communications into the Freshman engineering sequence, and discuss some of the lessons that have been learned from this experience.

## 1. INTRODUCTION

In the 2004-2005 academic year, a two-quarter Freshman engineering sequence was replaced with a three-quarter sequence. One of the significant changes was the integration of technical communications into the Freshman engineering curriculum. Communication skills have been clearly identified as an essential skill for the modern engineering graduate (Katz, 1993; Sageev and Romanowski, 2001; ABET, 2006). However, in the past engineering students did not receive any formal instruction in technical writing or speaking, except when individual instructors included writing assignments or presentations in upper-level courses.

As illustrated by the course outcomes summarized below, a prominent objective of the new Freshman engineering sequence is to provide all students in the College of Engineering with a uniform introduction to technical communications.

***Course Outcomes:*** *Upon completion of the course, students will be able to:*

- *effectively work in teams to accomplish a goal. GE104, 105, 106*
- *use the engineering method to solve analysis and design problems. GE104, 105*
- *develop technical documents typical of engineering practice. GE104, 105, 106*
- *analyze and present data in appropriate formats. GE104*
- *organize and present an oral technical presentation. GE104, 106*
- *generate engineering drawings of a three-dimensional solid. GE105*
- *create simple computer programs to solve engineering problems. GE105*
- *generate and follow a project schedule. GE106*
- *validate designs using physical testing and other methods. GE106*

Integrating technical communications into the first-year Engineering curriculum has proven to be beneficial at several institutions (Lengsfeld, *et al.*, 2004; Pendergrass, *et al.*, 2001). At Ohio Northern University, this approach is expected to improve the writing and speaking ability of engineering students early in their academic careers. Including technical communications in courses taken by all Freshmen in the College of Engineering will provide students with a more consistent set of guidelines for writing and speaking assignments in upper-level courses. This should also reduce the burden on upper-level instructors when making such assignments. Finally, giving technical communications assignments that are directly related to analysis and design projects should emphasize the importance of communication skills in engineering practice.

The new Freshman Engineering course sequence is now being offered for the second year. This paper will review the changes that have been made, will discuss some of the obstacles encountered, and will present some of the lessons that have been learned from the experience.

## 2. CURRICULUM CHANGE

Under the previous curriculum (before 2004-5), Freshman engineering students took two introductory engineering courses: *GE101 Fundamentals of Engineering* and *GE102 Problem Solving and CAD*. The first course presented topics such as professionalism and ethics, basic computer skills (Microsoft Word, Excel, etc.), and engineering problem solving. The second course included a brief introduction to AutoCAD and a team-based design project. All Engineering students were also required to take the following two writing courses offered by the College of Arts and Sciences: *ENGL110 Writing 1* and *ENGL111 Writing 2*. Mechanical Engineering students were required to take *COMM211 Public Speaking* in the Junior year, while Electrical and Computer Engineering students were required to take *ECCS406 Engineering Technical Communications* as Seniors.

While there were a number of motivating factors driving curriculum changes within the College of Engineering, one significant factor was the view that our students were not adequately developing their technical communication skills during the Freshman year. There were several reasons for this deficiency. First, neither the engineering courses nor the humanities courses emphasized technical communications. Second, because *ENGL110* and *ENGL111* are not prerequisites for technical subjects, many students were able to delay their enrollment in these courses until their Junior or even Senior years. Finally, because these courses (and *COMM211 Public Speaking*) are taught by another college, students often do not consider these courses to be relevant to their engineering coursework.

It was decided that expanding Freshman Engineering into a three-quarter sequence would allow technical communications to be integrated directly into the engineering curriculum. The expanded course sequence would also provide more opportunities for team-based activities, and could include a more extensive design experience. The new curriculum

includes three courses (*GE104/5/6 Freshman Engineering 1/2/3*) which will be described in detail in the following section. Freshmen engineering students are still required to take *ENGL110 Writing 1*, but the content of *ENGL111 Writing 2* and *COMM211 Public Speaking* has been integrated into Freshman and upper-level engineering courses.

## 3. COURSE CONTENT

During their first year, all engineering students enroll in *Freshman Engineering 1, 2 and 3*. Currently, five sections are offered for each of the three courses, with typical section sizes ranging from 24 to 28 students. Sections are not segregated by major so each section may include Civil, Computer, Electrical, and Mechanical Engineering students.

In *Freshman Engineering 1*, students are introduced to the profession of engineering. Students learn the engineering method by working in teams to solve several analysis and design problems. Concurrently, students review the fundamentals of writing, learn to create properly formatted graphs and equations, and produce technical documents. Many of the writing exercises are assigned within the context of the team projects. Typical assignments in technical communications given during the first course include

- writing an essay on "Why I chose engineering"
- proofreading sample documents
- proofreading documents written by classmates
- creating properly-formatted graphs of experimental data
- submitting letters, memos, and formal reports related to class projects
- writing an essay which discusses an engineering ethics case study
- writing a review of a technical article
- giving a presentation on a technical subject

The second of the freshman engineering courses, *GE105 Freshman Engineering 2*, introduces students to two useful software packages: MATLAB® and AutoCAD®. Approximately five weeks is spent on each package. While MATLAB® is used primarily as a tool for teaching basic programming, its powerful graphing capabilities also allow the instructors to review the graphing lessons taught in Freshman Engineering 1. While learning to use AutoCAD, students are also introduced to the basic concepts of technical drawing and dimensioning. Typical assignments in technical communications given during the second course include

- producing properly-formatted graphs of discrete data and of functional relations
- producing orthographic projections which are correctly drawn and dimensioned
- submitting letters and memos related to Matlab and AutoCAD projects

The third course, *GE106 Freshman Engineering 3*, is a quarter-long, team-based design experience. Teams of three to five students work together for ten weeks to develop a design in response to a Request for Proposals issued by the instructor. Each group is required to provide the following during the course of the project

- letter of intent with resumes of each team member

- written and verbal proposal to the instructor, which includes an estimated budget, project schedule (Gantt chart), and descriptions of at least three potential designs
- decision matrix
- written and verbal progress report to the instructor
- final written report
- final verbal report to the class, with prototype demonstration

The project-centered nature of GE106 has been exploited to create assignments in which students present the same or similar information in both written and oral form, an approach which has been suggested by Piirto (2000).

## 4. ASSESSMENT

A multi-faceted approach to assessment is being implemented to evaluate student communication skills. This approach includes standardized testing, writing and speaking in context, and self-assessment surveys. While the assessment process is not yet complete, a description and some preliminary comments are provided below.

As part of a university-wide assessment program, freshman Mechanical Engineering students were given a standardized "cognitive learning assessment" exam in the Fall of the 2005-2006 academic year. Included in this exam was an evaluation of student writing skills. This exam will be given to the same group of students again at the end of the Sophomore year (Spring 2007). When the results of these exams become available, a detailed comparison will be made to gauge the degree to which the writing skills of engineering students may have improved.

Improvement in student communication skills is also being evaluated through classroom assignments which require writing and speaking in the context of other engineering assignments. Specifically, by the end of the 2005-2006 academic year students will have completed the following assignments in both GE104 and GE106:

- writing business letters and memos
- writing a formal engineering report
- giving a presentation on a technical subject

In GE104 these assignments are made in the context of short analysis, design, and research projects. In GE106, the assignments are made in the context of a quarter-long design project. At the end of the academic year, individual student performance on these assignments will be compared to determine the degree to which communication skills have improved.

At the midpoint of the Freshman year, a survey was conducted to record student evaluations of their own abilities. The survey asked students to rate their ability, on a scale from 1 (not at all) to 10 (very able), to do the following:

a) write memos and business letters
b) write an engineering report
c) include equations and numerical data in technical documents

d) generate properly formatted graphs of technical data
e) give a technical presentation
f) write script files using Matlab
g) create drawings using AutoCAD

Question (f) was included primarily as a control question, since very few students had indicated prior knowledge of Matlab before it was introduced in GE105 Freshman Engineering 2. In contrast, a number of students received some AutoCAD experience in high school. This was reflected in a comparison of the numerical results for questions (f) and (g). Results of the survey given to 63 students in January 2006 are shown in Table 1.

Table 1: Results of a self-assessment survey conducted in January 2006.

| Question | | Average | | | Std. Deviation | |
|---|---|---|---|---|---|---|
| | | 9/05 | 1/06 | Δ | 9/05 | 1/06 |
| a | memos/letters | 4.8 | 8.1 | 3.3 | 1.8 | 1.2 |
| b | engineering reports | 3.0 | 7.7 | 4.7 | 2.0 | 1.3 |
| c | equations/numerical data | 4.6 | 8.2 | 3.6 | 2.2 | 1.3 |
| d | graphs | 5.1 | 8.6 | 3.5 | 2.3 | 1.0 |
| e | presentations | 5.3 | 8.0 | 2.7 | 2.1 | 1.5 |
| f | Matlab | 1.3 | 8.0 | 6.7 | 1.1 | 1.5 |
| g | AutoCAD | 3.0 | 3.1 | 0.1 | 2.7 | 2.7 |

From the results of the survey, several conclusions can be drawn. Most students believe their communication skills have improved substantially during the first half of their Freshman year. While the most significant improvement (aside from Matlab) was in writing engineering reports, the perceived improvement in all aspects of technical communications was much greater than the standard deviation. The only exception was in response to question (g), where a negligible increase was expected since AutoCAD had not been covered yet.

This survey was conducted within days of a project submission which allows for some corroboration of the data. Teams of students were required to write a Matlab program which read a data file, performed certain calculations, and generated graphs of the results. The project submission included a cover letter in "semi-block" format. Out of a sample of 25 letters, only two teams did not use the proper format. (Both of these teams used a memo format.) In all of the letters submitted, grammar, spelling, and word usage had improved noticeably compared to similar letters written in the previous Quarter. Of the same 25 teams, three did not submit properly-formatted graphs, primarily due to incorrectly labeling the graph axes.

## 5. LESSONS LEARNED

In the second implementation of these courses, several changes have been made to better achieve the goals of the sequence. This section discusses several of the more significant changes related to technical communication.

During the first offering of GE104, the technical communications portion of the course was provided by an adjunct faculty member. While this reduced the grading workload of the engineering faculty, it also caused scheduling conflicts among the multiple sections. More importantly, this may have given the impression to some students that the full-time engineering faculty did not consider this topic essential to the course – a student attitude that has been reported elsewhere in the literature (Lonsdale, *et al.*, 1995, Piirto, 2000). This year, all of the content has been covered by a team of engineering faculty.

Students were initially required to keep journals which recorded their weekly activities. This is now being assigned in an "orientation" type course. While this was certainly a writing activity, it was being done more to encourage students to manage their time well than for them to improve their writing. As such, it was more appropriate in the orientation course.

A common complaint of students is that, as they progress through the curriculum, every instructor has a different set of requirements when grading writing assignments. It was decided that the most effective way to address this issue is to require each student to purchase *A Guide to Writing as an Engineer*, by Beer and McMurray (2005), which is now used as a text in GE104, and as a reference for GE105 and GE106. It is expected that as the current Freshman engineering students advance, this book will also be used as a reference for writing assignments in upper-level electives, resulting in a more consistent set of expectations and guidelines within the College of Engineering.

Although this year is still 'in progress,' several things have been noted for improvement for next year. First, based on student feedback, the technical communication content in the first course will be spread out a bit. This year, the course began by focusing on technical communications before progressing to several hands-on projects and reports later in the quarter. Second, less lecture time will be used for reviewing basic writing (grammar, punctuation, word usage, etc.). Third, proofreading assignments will be given earlier in the course in order to encourage students to begin proofreading their own documents.

The survey discussed above will be given again at the end of the year to assess progress. At that point, other potential changes for next year's course will be considered by the team of faculty that teach these courses as part of ONU's standard continuous improvement process.

## 6. CONCLUSIONS

A number of advantages have become apparent from integrating technical communications into Freshman Engineering courses. Having this topic taught by the engineering faculty helps emphasize the fact that communication skills are necessary for successful engineers. Giving writing assignments and presentations in parallel with design and analysis problems allows students to improve their communication skills in a way that is clearly tied to their creative and analytical abilities. Introducing these topics early in the first-year curriculum also allows them to be reinforced repeatedly. While the Freshman curriculum will undoubtedly continue to evolve, early results are encouraging. The authors are confident that this approach will help our students become more proficient in the technical communications skills that are essential to engineers in the workplace.

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