Training Civil Engineers to Communicate Effectively: Teaching Technical Communication in a Student's First Engineering Course

Abstract

ABET requires that graduates of accredited institutions have "an ability to communicate effectively." The importance of effective communication of technical information is also addressed in the ASCE Body of Knowledge. How schools meet this outcome varies by institution but about half of the schools surveyed for this paper require a specific course on the subject. Constraints at the United States Military Academy (programs can not extend beyond four years and a very large core curriculum) make it impractical to require a technical communications course. In order to educate our graduates about this specific type of communication rather than simply have them "learn by doing" in their engineering courses, the Civil Engineering program now includes an introduction to technical writing in the first engineering course our students take. By using a number of short, focused reading assignments from a technical writing guide, several short memorandum assignments, and a complete laboratory report, students taking Fundamentals of Engineering Mechanics and Design now leave with one more fundamental – the ability to effectively communicate technical information. This paper discusses our experience of teaching technical writing in an existing introductory engineering course and includes feedback from students and instructors as well as some of our lessons learned.

Introduction

One of the outcomes of ABET-accredited institutions is that graduates have "an ability to communicate effectively."[1] The ASCE Body of Knowledge expounds on this outcome stating that engineers must be capable of "interacting effectively with technical and nontechnical or lay individuals and audiences in a variety of settings."[2]

The complete method schools use to prepare students to meet these outcomes varies but many include a specific course on technical communication. A survey of civil engineering curricula at 18 public and private institutions of varying size showed that only half have a specific requirement for technical communication and one offers a similar course as an elective (see Appendix A). Two of the nine schools requiring a technical communications course require two such courses, the rest require one course. Of those requiring a course, four require the course of their sophomores, three during the junior year, and two require the course in the senior year.

Background

Deciding which courses to require is a challenge for programs – especially those that desire to maintain a four year bachelor's program. The United States Military Academy (USMA) must keep the program to four years and given the very broad core curriculum required of all USMA graduates, the first engineering course is not taken until the second semester of their sophomore year. With only 5 semesters to fit in an ABET accredited program, our leadership must be very

judicious with course choices. For this reason, a technical writing course is not included in our curriculum.

Although a course is not specifically required, the importance of training our students in technical communication is absolutely critical. Regardless of technical branch within the Army, the majority of the communication an officer prepares is technical in nature and is, in many cases, provided to individuals outside of the technical field. The engineering education gained as a student at USMA has importance even if our graduates do not serve as practicing engineers. This makes the need for teaching and practicing technical communication even more vital.

By the time students begin the civil engineering program at USMA, they have been required to take two English courses – one composition course and one literature course. They have had opportunities to improve their communication abilities in many other courses by preparing reports, presentations, and essays across numerous disciplines. Aside from a few lab reports in the core chemistry and physics courses, however, the students have no exposure to technical communication.

The literature and composition courses which the cadets take at USMA do not adequately prepare them to communicate technical information effectively. Many of our cadets perform quite well in the required English courses, but struggle with the task of technical writing because it is fundamentally different. In a recent article on the topic of undergraduate engineer writing, Schnieter commented on these differences, stating: "English composition allows readers to provide their own interpretations of what the reader intended. Technical writing, on the other hand, demands that the reader come only the conclusion intended by the writer"[3]. Developing strong technical writing skills requires practice and this practice must come in the context of the engineering discipline.

In CE300, Fundamentals of Engineering Mechanics and Design, students are required to complete a uniaxial tension test of three different materials, draw conclusions about the materials, and write a comprehensive report including procedures, data, and findings. This lab is conducted in teams of 3 or 4 students. Historically, the effectiveness of the lab has been rated very low by our students in course-end-feedback surveys. The primary reason for the low ratings cited by students is the disproportionate amount of time spent on preparing the report when compared to other assignments of similar point value.

In discussions with students and faculty, the conclusion was reached that the main reason students were spending so much time on the report was not the technical details of the requirement; rather, the time consuming part was formatting, writing properly, and generally preparing a complete technical report for the first time. The report yielded lower grades when compared to the rest of the graded requirements of the course which was disappointing to students and instructors alike.

Previously, students in CE300 had been provided with a document prepared by our faculty titled "Standards for Technical Reports" which outlined the required format for various types of reports (design, analysis, and laboratory). This resource provided minimal discussion and focused primarily on required formats. The document did not discuss differences between other

types of writing and technical writing, nor did it address grammar and general technical writing fundamentals. Its primary focus was formats. As such, it was a valuable reference to someone with a background in technical writing but was inadequate for the novice.

Teaching Technical Writing In An Engineering Course

Since adding an entire course devoted to technical communication prior to taking CE300 was not an option, the only choice was to incorporate some education on the topic within this course. One thought was to continue to use the "Standards for Technical Reports" and add some partial lessons to discuss the various components of the report in class. This was quickly abandoned since CE300 is already very content rich and there were no obvious topics to cut in order to make room for such additions.

Dissatisfaction with the "Standards for Technical Reports", which was last updated in 1991, necessitated a revision of the document. Knowing that this would a very time-consuming task and realizing that there are many excellent technical writing resources on the market, we examined several existing reference books about technical writing. After staffing, we chose a reference that was complete, written with both budding and experienced engineers in mind, and provided numerous images of properly formatted portions of reports, memorandums, and other common written products required of an engineer.[4] We also provide students with a copy of a short, useful article written for students and faculty by an engineering professor.[5]

Several Universities have addressed this same issue in their Engineering programs through a formal writing across the curriculum program and writing to learn assignments. These comprehensive program level technical writing strategies focus not only on writing but also public speaking, presentations, workplace communications and collaborative writing[6,7]. While this certainly is a long term goal for our program, our first concern was to introduce cadets to the differences between technical writing and the composition writing and prepare them for their lab report assignment in CE300. As we looked to achieve this goal, we needed to be conscious about over-burdening students with additional assignments in a very full engineering course.

As previously mentioned, adding content to lessons was not practical. Instead, the approach taken was to develop components of effective technical writing one at a time over the course of 12 lessons through quick explanations and selected readings from the writing text chosen. Our focus is on helping students transition from the type of writing they are used to producing to effective technical writing. The seven assignments during those first 12 lessons are listed in Table 1. Each assignment is less than 10 pages of reading. Details of each reading assignment are included in Appendix B. Some time is spent during lesson 1 introducing the concept of technical writing and the writing program in the course. A small amount of time is spent in subsequent lessons touching on highlights from the readings about technical writing.

Table 1 Technical Writing Reading Assignments

	Theme	Number of Pages to Read
1	Do I Really Have To?	3.25
2	Writing Basics	5.50
3	A Few More Writing Basics	5.00
4	Report Basics	9.25
5	Details of a Technical Report	3.50
6	Editing and Teamwork	8.00
7	Lab Report Time Is Near	3.25

The reading assignments begin with an explanation of why it is important for an engineer (and in our case an officer) to be able to communicate technical information effectively to individuals within and outside of the technical field. The next readings then address the details of technical writing: writing clarity, appropriate use of passive and active voice, and effective transitions. Since the largest writing assignment in the course is a laboratory report, the next reading assignments begin to address specifics of such a report. Students read about document specifications, logical presentation, appropriate use of lists, equation, graphs, and tables, proper formatting, and citation. Finally, as the lab report nears, the reading assignments focus on the challenges of writing as a team, the importance of good editing, and the format for a laboratory report. For each short reading assignment students answer a few short questions to assist their synthesis of the information and to prompt their thinking about the approaching report requirement. Points associated with these questions are minimal since the primary goal is to engage students on the topic of technical writing – greater points are associated with the actual writing assignments when they demonstrate what they have learned.

In order to develop effective technical communication skills, cadets must practice writing. In addition to the laboratory report, students are required to write several memoranda during the course. Each of these is associated with a problem set and uses a format provided in the writing guide. A couple of these memos are simply summaries of the results of the work in the attached problem set – a cover page of sorts. Others are recommendation memorandums based on their work on a specific problem or series of problems. For example, in a problem set about beam design, students are given cost data for two types of steel with different strengths and are asked to design the most cost effective beam cross-section and write a recommendation memo that clearly states the most effective beam designed and its associated cost and briefly describes other options considered. Also, after watching a presentation of a senior capstone project of their choosing, the students in CE300 write a one-page summary and assessment of the presentation.

The short writing assignments (memoranda) are not directly linked to the reading assignments about technical writing. They do, however, increase in detail and scope over the course of the semester as students learn about various aspects of technical writing. Each assignment is graded for technical content but, with the exception of the lab report, the majority of points are allotted to the writing itself. The memos are graded for format, organization of thought, grammar and spelling, word choice, and overall effectiveness of communication. Some may argue that engineering instructors are not qualified to grade such assignments since we are not trained as writers. Given the amount of reading and writing that each of us do in the course of our duties,

however, we are certainly experienced with what effective writing looks like. As professionals, if we feel unqualified to grade things like grammar, we owe it to ourselves and our students to improve our abilities until we feel comfortable assessing student abilities in such fields.

Does It Work?

The program has only been implemented for two semesters so it is not possible at this time to assess its effectiveness within the context of the entire civil engineering program. It will take several semesters until instructors in subsequent courses see if there is an improvement in the writing products submitted in upper-level courses. Student feedback at the end of the first semester of implementation is positive, however. The 07-2 (the semester of implementation) course-end-feedback about the laboratory contributing to learning was a full point higher (on the 5-point likert scale) than two semesters ago and was improved from the previous semester as depicted in Figure 1. Since nothing else about the lab itself changed, at least some of this increase is certainly attributable to the improved integration of technical writing education in the course. This trend continued in the feedback from 08-1. Note that the students enrolled during "-1" semesters are predominately non-engineering majors while in "-2" semesters, the students are nearly all engineering majors. With this in mind, the increase between 06-2 and 07-2 becomes even more striking.

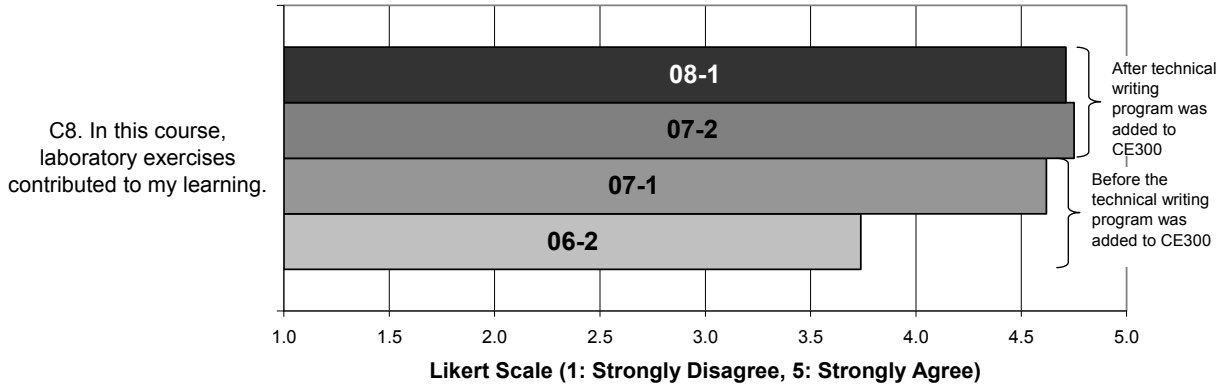

Figure 1 Course-End-Feedback

As can be seen in Figure 2, students also rated the writing guide relatively high and agreed that the writing assignments and readings from the guide were beneficial to learning. The main reason for the lower rating concerning the assigned readings in 07-2 was thought to be primarily due to the way in which assignments were made. They were not incorporated into the study guide nor were they part of a problem set. In other words, they were something else for the students to keep track of for the course and from their perspective were administered in an unorganized manner. This was improved for 08-1 by embedding the assignments along with some background information about technical writing directly into the course study guide. We believe we did not see improvement primarily due to the different populations: non-engineering majors tend to rate the course slightly lower than do engineering majors. This is an area that we are monitoring this current semester.

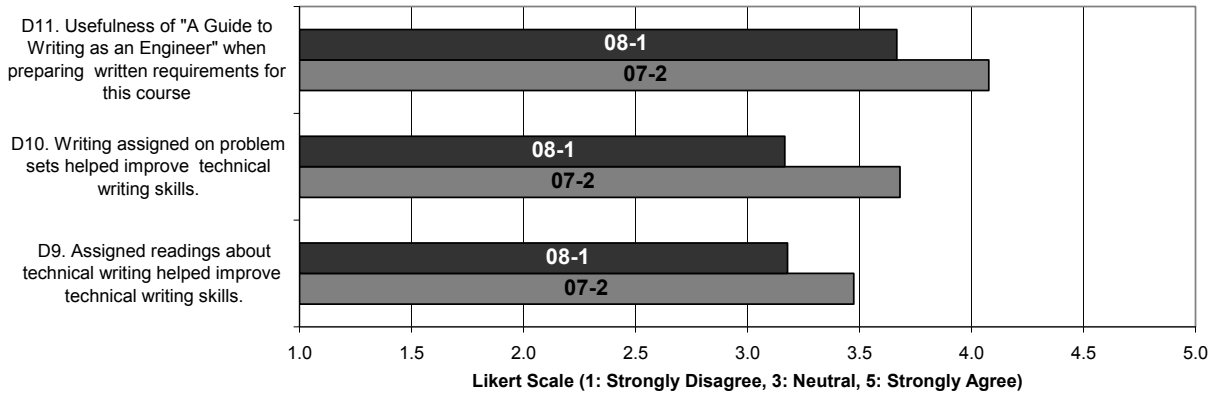

Figure 2 Course-End-Feedback Specific to Technical Writing

Ideas For Improvement

As we continuously work to improve this technical writing program, we decided to implement a few changes this current semester (08-2). First, we are modifying several of the short writing assignments assigned as part of a problem set. The students will be required to explain something from a homework problem – perhaps the significance of an answer or what the answer means in physical terms. By so doing, we will not only provide a means for improving technical writing abilities, but will also raise their level of understanding of the technical material.

Another new requirement this semester will be for the students to submit one homework problem typed. This requirement will be due prior to the production of the lab report. The intent is for this exercise to familiarize the students with equation editing software, embedding necessary sketches, and practice explaining the steps involved in solving the problem.

Conclusions

Given the challenges of improving technical communication abilities of our students with the constraint of being unable to add a course dedicated to the subject, the Civil Engineering program at USMA incorporated some instruction on technical writing into the first engineering course taken by our students. By doing so, we provided the students with an excellent technical writing reference, made them familiar with the reference through short assigned readings, provided the opportunity to practice through the completion of short memoranda as part of assigned problem sets, and culminated with the writing of a complete laboratory report. Feedback from students was positive and the instructors agree that the written products this semester were generally better than previous semester. To date, the technical writing program appears to be a beneficial solution that will prove to be successful.

In coming semesters, we will continue to assess and improve the incorporation of technical writing in CE300. Additionally, we will gather data from subsequent engineering courses to determine the effectiveness of this early introduction to technical writing. Finally, as our program matures, we intend to investigate the viability of a five-semester technical writing program with different aspects of technical writing interspersed throughout the program of study.

Bibliography

[1] Program Outcome (g): ABET Engineering Accreditation Commission, "Criteria for Accrediting Engineering Programs", 2007-2008 Accreditation Cycle, March 17, 2007

[2] Commentary for Outcome #7: ASCE, "Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future", ASCE, Reston, VA, 2004

[3] Schneiter, R. (2003) "Writing and Undergraduate Engineers – A Continuing Problem." Proceedings of the 2003 American Society of Engineering Education Annual Conference, Nashville, TN.

[4] Beer, D. and McMurray, D. (2005) *A Guide to Writing as an Engineer*, 2nd Edition, Riley, New York

[5] Evans, M. (1995) "Student and Faculty Guide to Improved Technical Writing", *Journal of Professional Issues in Engineering Education and Practice,* 121(2), 114-122.

[6] Hendricks, R.; Pappas, E. (1995) "Writing- and Communications-Across-the-Curriculum in the Materials Science and Engineering Department at Virginia Tech." Proceedings of the 1995 Frontiers in Education Conference.

[7] Coney, M.; Ramey, J. (1984) "A Communication Curriculum in Engineering Education: An Alternative Model." Institute of Electrical and Electronics Engineers Transactions on Education, E-27(3), 137-142.

Appendix A: List Of Schools Included In Discussion
[*information below was retrieved from on-line course catalogs reviewed during January 2007*]

Require **some type of course in technical communication**

Institution	*Year Taken*	*Course #*	*Course Title*	*Credits*
South Dakota School of Mines	Sophomore Junior	ENGL 279 ENGL 289	Technical Communication Technical Communication II	3 3
University of Delaware	Sophomore	ENGL 410	Technical Writing	3
Syracuse University	Senior	WRT 207	Technical Writing	3
University of North Carolina at Charlotte	Sophomore	ENGL 2116	Technical Writing	3
North Carolina State University	Senior	ENG 331	Communication for Engineering and Technical Disciplines	3
University of Maine	Sophomore Junior	ECP 225 ECP 366	CE Technical Writing I CE Technical Writing II	1 2
University of Illinois at Urbana / Champaign	Junior	B&TW 261	Technical and Scientific Communication	3
Mississippi State University	Junior	GE 3513	Technical Writing	3
Rose-Hulman Institute of Technology	Junior	RH 330	Technical Communication	4

List a course in technical communication as an *elective*

Institution	*Course #*	*Course Title*	*Credits*
University of Wisconsin at Milwaukee	ENG 206	Technical Writing	3

Do not require **some type of course in technical communication**

University at Buffalo
Union College
University of California at Irvine
Iowa State University
Cooper Union
University of Tennessee
University of Wisconsin at Madison
The University of Notre Dame

Appendix B: Details of the Technical Writing Development Program Assignments

	Theme	Pages from Reference	Pages of Reading	Section Titles
1	Do I Really Have To?	4-7 (Beer)	3	"A Successful Engineering Career Requires Strong Writing Skills" "Engineers Can Learn to Write Well"
		114-115 (Evans)	0.25	"Importance of Good Writing"
2	Writing Basics	28-36 (Beer)	5	"Express Yourself Clearly" "Use Efficient Wording"
		115 (Evans)	0.5	"Writing Clarity"
3	A Few More Writing Basics	57-59 (Beer)	2	"Active or Passive Voice?"
		118 (Evans)	0.5	"Impersonal Writing and Passive Voice"
		61-63 (Beer)	1.5	"Transitions" "Sentence Length"
4	Report Basics	36-37 (Beer)	1	"Manage Your Time Efficiently"
		17-19 (Beer)	2	"Satisfy Document Specifications" "Get To The Point"
		20-26 (Beer)	6	"Present Your Material Logically" "Make Your Ideas Accessible" "Use Lists For Some Information"
		115 (Evans)	0.25	"Good Organization"
5	Details of a Technical Report	70 (Beer) (see also Fig 3-3 on pg 71)	0.5	"Equations"
		153-154 (Beer)	1	"Graphics and Tables: Guidelines"
		234-241 (Beer)	2	"Citing Information" "A System for Documenting Your Sources"
6	Editing and Teamwork	70-72 (Beer)	1	"Edit, Edit, Edit"
		135-137 (Beer)	3	"Clarity of Writing Style", "Paragraph Structure", "Grammar, Usage, and Punctuation"
		117-118 (Evans)	1	"The Computer Age"
		242 (Beer)	0.5	"Tampering With Results"
		38-40 (Beer)	2.5	"Share The Load: Write as a Team"
7	Lab Report Time Is Near	119 (Evans)	0.25	"Students"
		92-93 (Beer)	1	"Some Preliminaries"
		96-98 (Beer)	2	"Laboratory and Field Reports"