Writing and Undergraduate Engineers - A Continuing Problem

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Introduction

Essentially any published paper that addresses either the engineering curriculum or deficiencies in the skills of practicing engineers includes conclusions regarding the need to improve capabilities in written and oral communication.[2,9,11,12,13,17] In the Report of the Committee on Evaluation of Engineering Education published in 1955, the Committee considered "insistence upon the development of a high level of performance in the oral, written, and graphical communication of ideas" an essential element of the engineering curriculum.[1]

Surveys conducted of civil engineering students and graduates at Virginia Military Institute (VMI)[6,7,8] and Lamar University,[12] as well as likely hundreds of other unpublished surveys conducted by engineering departments lead to conclusions that engineers need and want better communication skills to effectively perform in their careers.

Written and oral communication has been recognized as an important element of engineering education for nearly 50 years.[1] Many suggestions have been offered on how to encourage engineering students to write using a variety of instructional tools, by developing specific technical writing courses, and by a proliferation of writing across the curriculum (WAC) programs and writing centers at colleges and universities in the United States.[3,5,10,15,16] Furthermore, a study conducted at Virginia Tech revealed that engineering students have high standardized-test verbal scores and other attributes suggesting that they should be capable writers and oral communicators, but they are not.[10]

This history of apparent conflict between engineers' technical capabilities and their written and oral communication skills begs the question of why is there a problem and how can it be overcome. If undergraduate engineering education is to succeed in developing graduates with effective technical writing skills, the following four basic issues must be resolved: 1) Technical writing is not English composition. 2) Engineering faculty must consistently demonstrate that technical writing is a required engineering skill. 3) Technical writing can only be taught in context. 4) Technical writing requires a lot of practice.

Technical Writing is Not English Composition

Technical writing is not English composition. Kent M. Black, then Executive Vice President and

COO of Rockwell International Corporation said in 1994, when discussing his views of engineering education:[4]

> "I strongly disagree with this approach [of including mandatory non-engineering electives into the engineering curriculum], but hasten to add that there are non-engineering skills and disciplines that *are* important: Verbal and written communication - but obviously, technical and business writing are different from poetry or great literature - a point that is sometimes not recognized..."

English composition and, arguably, technical writing taught in the English department, are likely to be interpretive exercises devoted more to the creative process of writing rather than the concise and succinct presentation of technical information. English composition allows readers to provide their own interpretation of what the writer intended. Technical writing, on the other hand, demands that the reader come to only the conclusion intended by the writer. This is an important difference. Engineers write to convey technical information that needs to be understood by the reader as they intend it to be, with very little subjective interpretation. The whole purpose of engineering work is lost if engineers cannot clearly articulate the meaning as they intend it.

A study conducted in the Civil Engineering Department at Lamar University illustrates the dichotomy between the writing taught in English composition and the communication skills required by engineers. In the survey involving engineering students, 50% indicated that credit requirements in English composition and literature should be decreased, and 26.5% of practitioners agreed. However, 14.3% of students and 35.7% of graduates surveyed expressed a need for increased proficiency in technical writing skills.[12] Survey results suggest that the English composition and literature courses are not filling the needs of engineers in developing their technical writing skills.

Surveys of VMI alumni (beginning with the 1987 graduating class) and their employers report written communication as one of the highest rated deficiencies for the civil engineering graduates.[6,7] These results are surprising considering that since at least 1955, the VMI core curriculum has required two semesters of freshman English composition and, until 1996, required one semester of literature. In the face of the required three semesters of composition and literature, the perennial issue of deficient technical writing skills among VMI engineering graduates, and surely engineering students in colleges and universities throughout the United States, suggests that the English department is not the place to teach engineers to be proficient technical writers. Of interest here, also, is that engineers apparently do not easily transfer knowledge from English to technical writing and that we should, possibly, not expect them to become proficient technical writers from their writing experiences in English classes.

In order to write, one needs a topic. English professors can assign technical reading or require a search of scientific literature to provide engineering students with technical subject matter. However, English professors are ill prepared to engage engineering students in a discussion of

technical issues currently relevant to the students' course work, or to share personal experiences with engineering report writing, or to understand students' writing from an engineer's view point. English professors are not familiar with engineers' thought processes and are not prepared to direct students in clarifying engineering concepts through writing. In an effort to compensate for these deficiencies and simply get to the issue of writing, English professors may require reading from literature, poetry, non-fiction, and other sources familiar to them. In this later case, the objective of developing technical writing skills is unavoidably lost. Alternatively, where technical writing is taught by engineering professors, these barriers are naturally eliminated. A note received from a "writing expert" by an engineering professor concerning a consultation with an engineering student at a campus writing-center illustrates this point.

> "The student's paper had little interest from my point of view because it simply detailed the obvious... [B]ut I am not sure how he can interest a reader in the fact that treatment plants purify water."

Motivation to write technical papers is something that engineering professors are much better able to promote than are English professors. Engineering professors understand the role that writing plays in professional work and can share their personal experiences to emphasize its importance to their students. When writing is relegated to the English department, engineering professors are excluded from this interaction and students lose a more meaningful opportunity to develop their technical writing skills.

Technical Writing is a Required Engineering Skill

Engineering is closely allied with mathematics. Our students take classes in calculus, differential equations, linear algebra, numerical methods, and so on. Then, we make them use those math skills in nearly everything else we do. If they cannot do math, they cannot be engineers. No one will deny that math is essential to engineering work and that it is an important mode of technical communication that we value. The issue, however, is how engineering work is presented to those whom we desire to benefit from it? Do we give them a number or a sentence, an equation or a paragraph? Yes, mathematics is important and because it is so, we teach it and reinforce it in most of what we do. Can we see technical writing, too, as an important engineering skill and, like math and other technical skills, teach and reinforce it in most of what we do?

Typically, our work product is not simply a spreadsheet, calculations, or tables of neatly aligned data and results. After all, the engineer's product is, literally, a written document in the form of a letter, memo, report, proposal, specification, or something else that requires mastery of technical writing. When we teach technical skills, without adequately emphasizing writing skills, we deprive our students of the method of conveying their knowledge to those who would benefit from it, and we limit our students' professional opportunities. When this happens, we are negligent in our responsibilities to our students and fail to provide them with all the tools required for their professional success. We would never dream of depriving them of a complete experience in mathematics, yet we may be overlooking the important role of writing in

engineering work. This role is to present technical knowledge in an acceptable format according to the conventions of the discipline so it can be shared.[21]

The connection between technical and writing skills in engineering is well recognized by those both inside and outside of engineering. For example, Swartz and Odell,[19] both linguists and not engineers, assert that communication is "an essential, integrated part of working as an engineer" and that "writing is vital to quality engineering design. The process of carrying this task out is itself an act of engineering." They conclude with the bold statement that "rather than simply the manner in which engineering design is communicated, writing is the medium through which quality engineering design becomes possible."

An example illustrates the intimate connection between writing and engineering:

> Engineers are writing a report for presentation to a client. They are writing about what their firm learned about environmental contamination from the client 's manufacturing operations. In writing the report, the engineers may never visit the client's facility. Instead, they work from a file of company documents. The source for knowledge about the facility is not from personal observations, but from the writings of multiple other people.[20]

In this example, the engineers' sole function is to interpret the writing of others and present it in a written document of their own. What they have done is as much engineering as designing a column or footing, and it required technical expertise, but they would not have been capable of accomplishing this engineering task without writing.

The need among engineers for better writing and other communication skills increases as the graduate advances professionally, possibly as reliance on entry level technical skills decreases and reliance on communication skills increases. Although anecdotal, personal professional experience teaches that professional advancement is correlated to the ability to write well. In many, and possibly most, professional settings, this becomes obvious as the writers advance and the non-writers languish.

A survey conducted of the VMI civil engineering graduating classes from 1973 to 1998, based on 662 respondents, shows that as one matures professionally, the time devoted to engineering work diminishes as time devoted to management increases.[8] The survey results are presented in Figure 1 and allow a general conclusion. In particular, it is reasonable to expect that as one moves from mostly technical work to mostly management work that writing and other forms of technical communication acquire increasing importance.

To enable engineering students to become better technical writers, engineering faculty must consistently demonstrate that competent technical writing is required for work as a professional engineer, that it becomes increasingly important as one matures professionally, and that it is a necessary component of professional advancement. This means that faculty must make a

commitment to routinely including technical writing in their courses, to evaluate its quality and provide feedback to develop improved skills, and to otherwise establish in their student's minds that it is vital to a successful engineering practice. Volumes have been published on how this might be accomplished and will not be reviewed here.

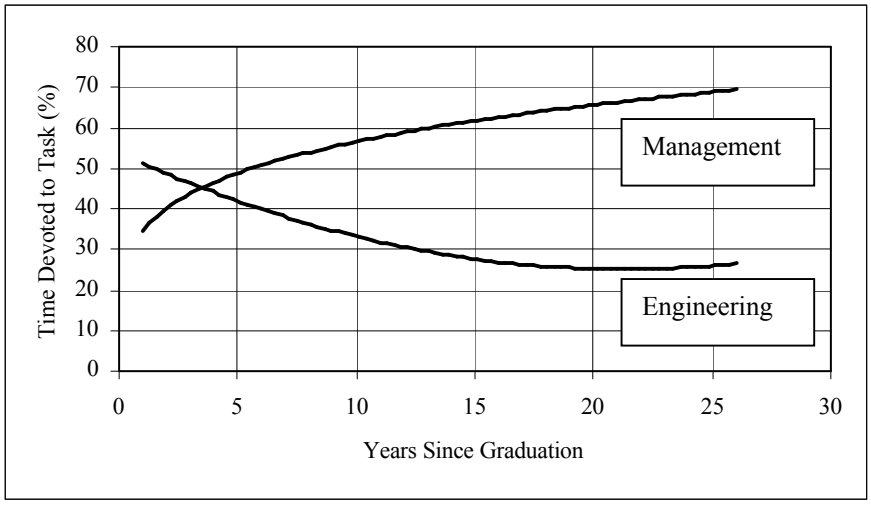

Figure 1. Professional Time Allocation Following Graduation

Technical Writing Can Only Be Taught In Context

Writing across the curriculum programs are popular among colleges and universities in the United States. These programs are usually sponsored by English departments, or at least involve English professors as chairpersons or directors and significant players who are there as cheerleaders promoting the value of writing to a sometimes disinterested science and engineering faculty. They are telling us what we should already know, that there is no substitution for teaching writing in the context of the academic major. In fact, the justification for WAC programs is that 1) college students need to become better writers, 2) they can most effectively do so in the context of their academic major, and 3) writing promotes active learning across the curriculum.

Of particular relevance to engineering, is the ability to translate technical concepts into clear, concise, and appropriate English that is easily understood by the target audience. This requires that the student write about technical issues in the style and format of the discipline and using the language of the discipline.[21] Style, language, and format define the convention of technical writing for engineers. Because of the importance of convention, it becomes difficult to develop true proficiency even as students move among the various engineering disciplines. For example, conventions employed in electrical engineering are different that those used in civil engineering.

Technical writing becomes discipline specific and can be best developed as a useful skill in the context of its application in engineering.

An interesting case is reported by Nixon and Fischer[18] and provides a quick study about writing in the engineering curriculum. The writing was associated with a sophomore-level class in statics, a topic usually thought of as all calculations with very limited opportunity for writing. Statics is an engineering topic that provides a foundation for more advanced courses, but sometimes leaves students wondering how it applies to their future work as an engineer. That is, how is it relevant to them? This question cannot be answered with a mechanical pencil and a calculator. It can, however, be answered through a writing assignment. In fact, a limitless opportunity exists to incorporate writing into essentially any engineering course. If it can be done with statics, it can be done anywhere else in the curriculum. When it occurs in the context of engineering courses, it becomes relevant to engineering students.

Where else but in engineering courses can students be provided the opportunity to write a design memo or specification? Both of these are directly relevant to structural engineering, course work that is usually not associated with writing. Interpretations of groundwater contamination data or environmental regulations as part of routine homework assignments are relevant to geotechnical and environmental engineering. There is a long list of writing opportunities, all of which encourage writing's natural integration into the engineering curriculum. Students need to present data and results, to interpret results in concise and clear language, to develop a professional vocabulary and know how to use it, to completely formulate and defend a convincing technical argument, access, evaluate, and use technical literature, and develop a variety of other communication skills. If not in engineering classes, where else can the language of engineering be developed? Certainly, there is not a better place for them to have this experience than in the context of the course where writing is used as the medium to communicate the professional work product.

Students frequently have difficulty making connections among the various classes they take, especially those that are associated with disparate disciplines. Many students miss the connection between English and engineering, for example. With this disconnect, students either do not transfer the skills learned in English to engineering, or they experience a delay in their application. In either case, the issue of context becomes important in overcoming this disconnect and allowing students to develop technical writing skills early on.[14] What context provides is the link between writing and engineering, that if established as an integrated element of all engineering course work, helps students develop into mature writers in the technical language and style used by engineers.

Although VMI has a well-developed WAC program, a writing help-center, requires two semesters of freshman English, includes a writing intensive requirement for all students, and applies additional effort to promote writing, the students perceive writing as external to engineering practice. Although we are making progress, writing is often something they suffer through and are anxious to discard as they meet the curriculum writing requirements. Writing does not fit into the context of engineering for these students. Without context, there remains a disconnect regardless of our best efforts. To achieve success in developing our students into effective technical writers, they have to see it as integral to professional engineering work.

Technical Writing Requires Practice

Regardless of how or by whom writing is taught to engineering students, proficiency will not result from that single experience alone. As with any skill, writing proficiency comes from practice. Writing experience must be frequent and consistent throughout the four years of a typical undergraduate engineering education. If this experience is to be frequent and consistent, it must extend into the engineering curriculum as an integrated element of many, if not all, engineering courses. As an integrated element of these courses, writing becomes a tool for teaching and learning engineering topics and is perceived by the student as a natural activity associated with engineering practice. Where writing occurs frequently, the student's perception of it becomes more positive, confidence increases, and ability is developed.

Significantly, the engineering professor can use writing as a tool to help students assess their own understanding of a subject, to develop their ability to critically analyze and solve a problem, and to provide direct feedback to the professor. The benefits increase with the frequency of use. Winsor has observed that the act of writing equates to learning, it is a method of analyzing and generating knowledge, not simply a means to pass it along.[21] Providing students with frequent writing opportunities in the context of their discipline, using the relevant conventions, enables thinking and broadens learning.

Conclusion

Resistance to writing in the engineering curriculum is sometimes associated with an added burden to professors who will have to read and grade the work. In addition, some engineering professors do not feel competent to evaluate writing. These are legitimate concerns and a review of the literature will show that a good deal has been published to help us effectively address them. Also, some faculty assert that their interest is not in teaching writing, but we have established that writing is engineering.

This paper does not advocate another new program. The literature is replete with examples and advice on how to teach writing in engineering. These should be consulted so that a maximum benefit results. However, the essential argument here is that it needs to happen under circumstances that present it as a fundamental part of professional engineering practice. If we can do this, success is more likely. If not, then we continue to feed the problem. Fancy programs promoted by a few interested faculty will never do the trick.

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