AC 2011-1503: WHY INDUSTRY SAYS THAT ENGINEERING GRADUATES HAVE POOR COMMUNICATION SKILLS: WHAT THE LITERATURE SAYS

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Why Industry Says That Engineering Graduates Have Poor Communication Skills: What the Literature Says

Abstract

Although engineering departments have worked hard at improving the communication skills of their students, a large percentage of industry managers consider the communication skills of engineering graduates to be weak. Why does industry consider these skills to be weak? Also, what particular aspects of written and oral presentation skills does industry consider to be weak in engineering graduates? This paper addresses these two questions through a review of multiple studies that have assessed the communication skills of recent engineering graduates.

Our review has found that part of the disparity arises because the communication assignments that engineering students perform in college significantly differ from the writing situations (audiences, purposes, and occasions) that engineering graduates encounter in industry. New engineering graduates do not typically possess the expertise to realize what communication principles from classroom assignments apply, or do not apply, in different professional situations. Yet a third problem is that what constitutes strong communication skills in professional engineering settings may differ considerably from what is taught or expected in classroom settings.

Although the literature provides these insights into the disparity, much still needs to be learned about the specific deficiencies in communication skills of entry-level engineers. One step that could be taken is for engineering departments to conduct longitudinal studies about how well their instruction on writing and oral communication prepares students for later classes, for internships and co-ops, and for employment. Departments at different institutions should consider adopting a core of common survey questions so that survey results can be compared.

Another recommendation is that when incorporating writing into a course, engineering departments should consider the following two questions:

1. What communication skills do we want students to acquire?
2. How can technical assignments be designed to help students achieve those desired communication skills?

To answer the first of these questions, engineering departments would do well to identify the specific communication traits that the employers of their graduates see as important. To answer the second question, engineering departments should consult with communication specialists, and preferably those familiar with the kinds of communication that engineers do.

Introduction

In a recent survey completed by the American Society of Mechanical Engineers (ASME),[1] 52 percent of mechanical engineering department heads considered the written and oral

communication skills of their mechanical engineering graduates to be strong, while only 20 percent considered these skills to be weak. Unexpectedly, a parallel survey of industry representatives found almost opposite results, with only 9 percent considering the communication skills of recent mechanical graduates to be strong and 52 percent considering those same skills to be weak. Given these results were gathered from 68 mechanical engineering department heads and more than 1000 engineers and managers, a disparity clearly exists between the communication skills we are teaching to engineering students and what industry expects our students to know.

Why does this disparity exist? Why does such a large segment of industry consider the communication skills of engineering graduates to be weak, especially given the attention focused in recent years on teaching engineering students to be effective communicators? Also, what specific aspects of writing and oral presentation skills does industry consider to be weak in engineering graduates? These questions are difficult to address for several reasons. First, industry does not speak as one voice; differences can exist among different professional engineers' definitions of strong writing and among the types of communication tasks undertaken, within a single company and industry, and even more across different companies and industries.

Second, much variety exists in approaches that different engineering departments take in teaching writing and oral communication skills to their graduates. For example, some departments emphasize writing long individual reports, but give little instruction on group reports. Other departments do the opposite. In addition, departments may emphasize specific types of communication, such as proposal writing, writing correspondence, making posters, or giving presentations. Which faculty creates the assignments and handouts, and provides feedback and grading, can and does vary significantly. These variations occur not only across different engineering colleges, but also within disciplines in a single college.

Despite these two challenges, this paper attempts to address the question of why the disparity exists through a review of two types of studies: (1) studies that have summarized what we teach engineering students about writing and speaking in our academic programs, and (2) studies that have assessed the communication skills of recent engineering graduates. What distinguishes this review is that the primary audiences for the review are administrators of engineering departments across the U.S. (most such reviews target technical communication experts). Second, our review focuses on possible reasons for the disparity that the ASME survey revealed.

How U.S. Engineering Students Learn Communication Skills

To frame any discussion of engineering students' skills in written and oral communication, it is important to characterize how these topics are presented to undergraduate engineering students. Engineering communication programs have greatly expanded since the Accreditation Board for Engineering and Technology (ABET) introduced Engineering Criteria 2000 a decade ago.[2] This expansion has produced a variety of approaches to teaching communication to engineering students, many of which include a number of collaborative variations between communication departments and engineering departments. These collaborations between departments required strategy and flexibility, enacted in the form of lecture schedules, task formulation, and grading

procedures. While this exchange impacts our students and the supervisors who will one day hire them, it is of interest to the writing across the curricula (WAC) community as well, because it illuminates the collaborative space on which all WAC programs are built.

Simply stated, WAC collaborations are built upon the answers to three questions:

1. What communication skills do we want students to acquire?
2. How can technical assignments be designed to foreground the desired communication skills?
3. How can technical instructors and communication instructors establish criteria for commenting on and grading student work that has both technical and communication components?

These questions are hard to answer, and our work suggests that they are answered differently for each engineering program. We will argue that this variation among programs contributes to the disconnect between classroom and workplace communication as captured in the ASME survey.

This literature review does not seek to answer these questions so much as to refine them by describing what we do and what we know about our domain of communication instruction. Relying on work by Leydens and Schneider,[3] we begin with a short history of technical writing program development since the announcement of ABET's EC 2000, taking note of the split between Writing Intensive (WI) approaches, which emphasize the integration of writing instruction into existing technical courses, and General Skills approaches, which offer stand-alone courses in professional writing. We will then present numerous critiques of the Writing Intensive approach, followed by modifications to this approach, particularly in the years 2007-2009. Then, in broader consideration of WI programs, we consider questions of control and authority that are latent in any WAC collaboration.

Table 1 provides a sampling of the structure of engineering communication programs across the country. Not shown in Table 1 is the typical freshman English course, which all students take. Also not reflected are the nuances on technical communication courses and writing intensive courses that engineering students take.

EC 2000 and the Development of WI and General Skills Programs. Although we are primarily interested in communication instruction, it is important to remember that ABET's evaluation criteria have come to embrace a number of non-technical skills since EC2000 was introduced. Siller's description of Colorado State University's Professional Learning Institute lists five areas of learning that have been added to that school's curriculum in order to meet the concerns of ABET and various professional societies: ethics, leadership, innovation, civic and public engagement, and global culture and diversity.[4] While the particulars of this program's implementation are not important for this discussion, Siller's paper makes it clear that communication skills are not being introduced to technical curricula in isolation. Curriculum committees in engineering colleges are taking up communication as a single part of a large effort to address the concerns of their many stakeholders. Wheeler and McDonald present a detailed Write-to-Learn justification for communication programs to promote development of WI programs in engineering programs generally.[5]

Table 1. How communication is taught in a sampling of engineering departments across the U.S.

Institution	Description of Courses and Instructors That Teach Communication Skills
Georgia Tech: ME, ECE, CEE, MSE, ChBE	Communication intensive courses in Engr. Department, co-taught by departmental communication faculty.
Penn State: BioE, ECE, ESci, ME	Technical writing course in English Department; speaking course in Communications Department; communication intensive courses in Engr. Department (taught by engr. faculty with help from COE communication specialist)
UT-Austin: BioE, CEE, ChE, ECE, ME	Technical communication course in Engr. Department (taught by Engr. Department communication specialist); communication intensive courses in Engr. Department (taught by Engr. Department faculty with help from Engr. Department specialist)
UW-Madison: ChE, CEE, IE, ME	Technical communication course in College of Engineering (taught by COE communication specialists); communication intensive courses in Engineering Department (taught by Engineering Department faculty)
Western Michigan: IME, ChE	1st-year technical communication course in College of Engineering (taught by COE communication specialists); communication intensive courses in Engr. Department (taught by Engineering Department faculty, some with communication background)
Virginia Tech: ECE	Technical writing course in English Department; communication intensive courses in ECE (taught by ECE faculty with help from COE communication specialist)
Virginia Tech: ME	Communication intensive courses in Department (taught by ME faculty)

As a complement to Sillers' work, Leydens' paper focuses sharply on the ways that communication instruction has evolved since EC2000.[6] In particular, this paper gives a strategic account of the impact of EC2000 on universities' composition and communication programs. In this version of the story, ABET's increased concern for students' writing and communication skills has placed burdens on both engineering / technical departments and on humanities departments, as the two domains moved to develop writing across the curriculum programs that would meet ABET's requirements. These programs generally took one of two forms:

1. Introduction of enhancements to existing technical communication courses,
2. Introduction of formal communication requirements for existing engineering project courses, which are then designated as Writing Intensive.

This split in the first generation of EC2000 WAC programs reflects the twin constraints of expertise and curriculum that all engineering programs must solve.[7] It also speaks to the difficulty of collaboration within these constraints, because neither approach to WAC introduces truly novel, hybrid courses. The problem is that instructors' expertise and time do not divide neatly, and projects from different disciplines do not always integrate smoothly. Consequently, these two flavors of WAC approaches, conducted primarily from (1) communication departments, or (2) from engineering / technical departments, may provide results that cannot be compared using current assessment methods.[8] The next two sections distill these two forms of engineering writing instruction from one another in order to offer separate evaluations of each.

Description and Critique of WI programs. Writing Intensive courses can address a number of curricular and practical goals. For writing instructors, such classes provide a well-defined scenario, subject, and audience for report writing. For engineering faculty, they offer a way to present communication instruction to students without adding hours to students' graduation

requirements. In addition, faculty members hope that such in-house instruction will improve the reports that they and other faculty must grade in subsequent courses.

Published descriptions of Writing Intensive programs tend to be formed as narrations rather than as descriptions. This is because WI classes require a great deal of debugging. Gragson tells a representative story of a chemistry laboratory class that was modified in an effort to promote general improvement in student writing skills by offering extended instruction on report writing and better writing feedback on graded reports.[9] To meet these goals, the number of project reports was reduced from 10 to 4, and the instructors created from scratch a writing manual for use in the course. An elaborate peer-review process was also implemented, along with a system for assuring that students actually performed their peer-reviewing tasks. This paper judges student performance to be satisfactory, but large questions remain open; student retention of the writing lessons was not assessed in subsequent classes or in the workplace. Yalvac *et al.* present a similar story.[10] Here also a research paper component was introduced into an existing bioengineering course in order to improve student writing skills generally and to improve student learning on particular topics. And here also the writing instruction component was adjusted over the course of several years in order to develop a project format and workflow that was congenial for the students and their instructors. As was the case for the Gragson paper, student communication performance in subsequent classes was not evaluated.

Many such stories have been told in the past 20 years. Ford and Riley offer an excellent cross section of these, although their paper largely indexes programs without analysis.[11] In implementation-oriented papers such as those presented here, authors took pains to demonstrate that their projects are grounded in WAC studies and in engineering education research. Yet these papers also remind us that WI courses are expensive endeavors in terms of the instructors' time that was devoted to creating writing resources for their particular courses and to adjusting project workflow for the specific mixture of students enrolled in their courses. And for all this investment in report writing and editing, the question of "What next?" is still harder to answer, for there is no reported evaluation of whether students were able to retain and use their new writing skills after they left these particular classes. Indeed, the writing skills of interest are themselves not sharply defined in most studies, nor is the relationship these skills might have with any activity or event outside of these particular classrooms. This ambiguity in the formulation of instructional objectives makes it hard to determine how success in one department might be translated into a similar success elsewhere.

Fundamental Problems with Classroom Instruction of General Skills. General skills technical communication courses—courses delivered outside of the student's major department—use a different approach to communication instruction and present different types of problems. These general skills classes are built up from existing technical communication courses, to which numerous modifications have been introduced since EC2000 was introduced. Sageev and Romanowski, for example,[12] explicitly polled recent engineering graduates to identify topics that should be added to future technical communication courses. This paper also provides references to numerous other papers presenting similar survey results.

However, the courses that incorporate these innovations are also heirs to a great deal of critique of classroom writing instruction. Wolfe questions the quality of classroom instruction in

technical communication by identifying problems in a dozen widely-used technical communication textbooks.[13] Kirkland presents a detailed review of the general disjunction between classroom writing and all other writing activities.[14] While Kirkland's paper does not address the particular concerns of engineering employers, it raises basic questions about the way classroom writing skills map onto tasks that students undertake outside of their classes.

Relatively few studies address skill transfer by assessing students' performance after they have completed a communication class. One such study was conducted by Hansen *et al.*,[15] who sought to identify what skills students retain from introductory composition courses and to compare these students' subsequent performance to the performance of students who used Advanced Placement credit to skip introductory composition. While Hansen's particular results do not map onto our area of engineering communication, this paper offers richly documented explanations of the logistical difficulty of assessing skill transfer, and the intricate balance between general guidelines and specific examples that it requires (for a richer discussion of this topic, one should see also Foertsch[16]). Hanson also discusses and frames the ambiguities raised by the changes in the students' rhetorical situations at the two periods of the assessment, pointing out the difficulty of measuring the impact of this important dimension of communication.

Hybrid Programs. Dissatisfaction with communication instruction is not limited to general skills classes. Two recent papers richly document the problems raised by WI instruction, and they resolve the problems by adopting a different approach to organization and sequencing the instruction.[17, 18] These papers present hybrid communication programs in which WI classes alternate with general skills presentations in the form of seminars or short courses, presented over several terms of the students' education. A third study also explores the problems of WI instruction, but addresses the problems by adjusting the communication situation rather than the instructional materials. Anthony argues that students best learn to function and communicate in their discipline when they work in mixed-discipline groups. In these groups, they learn communication standards by talking frequently to their colleagues.[19] In this approach, faculty members invest significant time in overseeing and guiding these cross-disciplinary discussions.

Strategic Issues: Control and Authority. Several papers raise the question of authority that is latent in many efforts to marry communication instruction with technical and scientific project courses. In all classes, these issues surface when grades are assigned and feedback is provided; engineering students are often reluctant to accept feedback from readers who are not in their fields, yet technical instructors are often ineffective at giving feedback that helps students to better understand good writing. For example, Taylor studies a flavor of WI program in which student lab reports are evaluated for writing as well as for technical substance. As in many laboratory classes, graduate teaching assistants do the actual grading, and Taylor shows that they are typically ill-trained and supervised.[20] However, Smith points out that technical faculty are consistently more effective than communication instructors at identifying technical errors in student reports.[21] Further complicating the authority problem, Cho explores the way people deliver communication feedback and the ways that students respond to it.[22] Cho finds that students respond best to feedback that is (A) positive and (B) directive—so long as the directives are non-trivial. In order to deliver non-trivial directive feedback, communication instructors must either be well-versed in the technical discipline where they are grading, or they must have strong insight into the ways that text structures reflect substantive information generally.

Another strain of research confronts the authority question by adjusting the scenario under which student communication takes place. This approach adopts the principles of Writing Activity Genre Research, arguing that communication is a situated activity and that a communication class must thus be driven by an activity that realistically simulates tasks and problems that students will one day encounter. The full formulation of this theory is found in Russell.[23] Spinuzzi and Leitão rely on it to account for the ways that writers adapt workplace report forms for particular audiences,[24] and for the ways that children modify the stories they tell when their audiences or rhetorical goals change. Stappenbelt shows that this approach can be implemented in a classroom by reframing the entire course as a project or a company, with the students in the class formed into project teams or small individual companies.[25]

If we fully embrace the notion of writing as a situated activity, we might conclude that classroom communication instruction, whether in the form of general skills classes or in the form of WI classes, can have only limited success in building genuinely useful and lasting communication skills. Tracking the experiences of novice engineers, four authors have made strong cases that communication instruction is necessarily completed in the workplace, not in the classroom. The classic work in this area is Dorothy Winsor's *Writing Like an Engineer*,[26] which tracks the professional socialization of a small number of engineering students. Leydens tracks the development of entry-level engineers as they are socialized into professional practice,[27] describing the novice's rhetorical initiation into the complexities of workplace communication as a continuum rather than a sharply defined process. In a separate study,[28] Brady observes roughly the same process, and partitions it into three well-defined stages. Katz considers the same issues,[29, 30] but focuses on the resources that novices rely on during the socialization process, such as mentors and example documents.

Regardless of what one thinks about Writing Activity Genre Research in particular, the creation of a communication situation for students is useful and interesting. Certainly engineering programs have long sought to develop classroom projects to address problems raised by corporate sponsors, and such projects commonly have a communication component, in the form of periodic formal reports delivered to representatives of the sponsoring companies. The advantages presented by introducing such corporate communication to a class may, however, be balanced by the risk of completely outsourcing communication instruction to industrial sponsors or partners. Fortunately, most sponsored engineering project communication is also graded by and commented on by the engineering faculty in charge of the course. And while it has been noted above that engineering faculty—and teaching assistants—are often ill prepared to give communication feedback, the interactions and exchange of knowledge provided through WAC collaborations over the last decade has strengthened many engineering faculty's ability to provide useful and informed feedback on communication. Adopting situated communication as a guideline for undergraduate programs seems to risk (at worst) eliminating communication instructors from the communication program or reducing them to the position of a committee member, with indifferent influence over the students and the program. At its best, however, coupling communication with situated project activities can result in helping students understand that communication is integral to, not separated from, their engineering tasks. This is especially likely when those teaching and advising project activities are themselves skilled communicators, in touch with industry expectations for professional communication requirements.

What U.S. Industry Says about the Communication Skills of Engineering Graduates

Compared with the number of articles describing what engineering departments should do to teach communication, the number of articles that capture what industry says about the communication skills of engineering graduates is woefully small. Paradis *et al.* in 1985 had one of the earliest studies in which they surveyed 33 new chemical engineering hires at Exxon.[31] What they found at that time was that only four of the new hires had taken a course in technical writing. Many of the new hires studied had gained their writing experience from laboratory courses, but the authors concluded that having students write lab reports that followed narrow templates was of little benefit to improving their writing skills.

Winsor's 1996 *Writing Like an Engineer* is often cited.[32] In this longitudinal study, Winsor interviewed four young engineers over a number of years, from when they were students to when they had become established engineers. One conclusion that she drew was that writing like an engineer happens through immersion in the workplace. Eventually, the workplace standards supersede those of school.

One of the most valuable studies on workplace writing was the 2001 PhD dissertation of Betsy Aller.[33] Aller surveyed 38 engineers who had between 0 and 10 years experience with large firms. In addition, she did in-depth interviews with 10 of those. In general, the respondents considered themselves to be successful writers; in some cases, this was verified by the new hires' managers. In her study, Aller focused on identifying the traits of effective writing in corporate settings, the typical documents engineers in industry wrote, and whether university classes prepared students for the communication tasks and needs of industry. Seen as most important in engineering documents were the traits of being *concise* and *well-organized*. What is important to realize here is that among engineers in the work place and those who teach writing, different meanings of *concise* may exist. For instance, for many writing teachers, being concise refers to eliminating needless words at the sentence level, but among engineers, being concise means that the entire document gets to the point quickly, omitting not just needless words but needless content, according to its intended audience. Another of Aller's conclusions was that fewer than half of the respondents wrote lab reports in the workplace, and fewer than 10% did so often. For this group, long reports were seen as atypical in the workplace – a finding somewhat at odds with a frequent method relied on for practicing communication skills in the university setting. A final, key finding was that while engineering companies expected and required their employees to be strong communicators, the companies did little or nothing to support new hires' training in expected communication tasks or qualities. In other words, the academic world has begun to understand that engineers learn much of their communication expertise through immersion in the workplace, but the workplace expects (or at least did in 2001) the academic world to fully prepare its engineering graduates in advance of professional practice.

A more recent study that included a perspective on workplace writing was the NSF-funded Academic Pathways study by the University of Washington in 2010.[34] While this study did survey and observe a large number of recent hires (100), the results as reported so far do not add much to what is already known. For instance, this study found, as the ASME study mentioned at the beginning of this paper,[35] that recent engineering graduates were often weak in skills relating

to communication. This study did find that communicating with non-engineers was sometimes unexpected by engineering graduates and often a stressful part of their new jobs.

In another recent paper,[36] Norback *et al.* adopted a tack similar to Aller's in which they tried to identify the traits of communication that industry desires. In this study, the authors interviewed and surveyed executives from different companies that hire graduates of the engineering department. The purpose of these surveys was to determine the executives' perspectives on the communication skills needed to be hired and to advance in their respective companies. Norback *et al.* catalogued the advice for different types of communication, such as communicating with senior management, making presentations, and face-to-face communication.

As would be expected in the Norback *et al.* study,[37] many recommendations from the executives concerned how engineers should communicate with executives. For instance, the executives emphasized that engineers be concise in their communications—using as few words as possible to get their message across. Along those lines, the executives suggested that engineers state their recommendations in the presentation, but save the details that support those recommendations for the question and answer periods. Another important observation was that executives' advice went beyond the commonly taught situations of engineers writing documents and making formal presentations. The executives also emphasized the importance of other communication skills such as listening, handling voice mail, meeting face-to-face without technology, and communicating across global cultures.

This same expanded definition of communication has arisen in the "How People Learn Engineering" project headed by Sandra Courter at the University of Wisconsin-Madison, which addresses the question of how engineers learn to communicate. In this case study project by Nicometo *et al.*,[38] interviews of engineers and their managers (N=91), and surveys of engineers and engineering managers (N=162), uncovered three main traits that engineers assign to "effective communication" in other engineers. The first trait is the ability to communicate the "big picture." That ability is the "ability to effectively speak, write, and interact with audiences who [are] outside of their specific discipline, work group, or focus." The second theme is the "willingness and self-motivation to initiate communication with others and to seek out resource information through informal interactions." The third trait is the ability to listen to others.

Reconciliation of What We Teach Engineering Students and What Industry Expects

The disparity between classroom writing and workplace writing has numerous sources. Chief among them are the elements of the writing situation that each establishes:

1. differences in the goals for writing in the classroom and for writing on the job, and
2. differences in the audiences for whom reports are prepared in the classroom and in the workplace.

It is possible for classrooms to simulate workplaces in the ways in which goals and audiences are defined, but such simulations require significant and sustained acts of imagination to make the simulation work for the whole of a school term. Universities have worked—with more or less success—to solve this problem by developing industrial partnerships for their courses to solve the

problems of audience, of reporting requirements, and of standards of clarity. Industrially sponsored courses may well help to narrow the disconnect which concerns us, although this solution to the problem comes at a high cost in terms of the logistics of establishing the relationships between companies and classes and of maintaining a flow of projects for new groups of students. Perhaps the best and most genuine of these industry-academic interactions for communication purposes takes place in the engineering capstone design courses, where students typically work for an extended period with corporate sponsors and faculty to provide a solution to a real engineering problem. In these very real settings, corporate relationships have already been established; projects are, of necessity, already procured; and the communication tasks are seen by students *and* faculty as integral to the engineering work.

For all the value we see in university-industry partnerships, it falls to us in the university to define the elements of communication that we seek to teach our students and to develop similar, sharp definitions of what our colleagues in industry seek in our students' communication skills. Specifically, we make the following two recommendations for engineering departments:

1. to define more sharply the communication skills that we want our students to learn, and
2. to define more sharply how we set our goals for student communication skills.

These two items speak to the meshing of the goals for teaching communication with the goals for teaching engineering. One concern here is that some programs adjust their report requirements to accommodate the grading in particular classes or to solve other practical problems in these classes. Some of the program summaries cited above hint at this tendency by describing processes of modifications in order to make communication projects fit with the logistics of the particular courses into which they are introduced.

As a first draft for the goals that we want to teach our students, we recommend that departments secure input from the people who manage the engineering graduates of those departments. For many graduates, those managers will come from industry; for others, some of those managers will be research faculty in graduate school. In essence, we recommend the direction taken by Aller and Norback *et al*., which is to determine from these managers the specific traits of successful engineering communication in that setting. One important consideration, though, for such studies is that what managers from industry report back in such surveys can easily be misinterpreted. For that reason, communication faculty with an understanding of engineering should help interpret the comments. A second consideration is that with a few aspects of communication, industry practices may lag behind what communication research is discovering to be the best practices to teach and for students to learn. For instance, such is the case with the design of presentation slides.[39]

Finally, we do not need yet another study that comes to the final conclusion that communication skills in engineering are important. No one disputes this. What we need is a study that mines down to determine what important things about communication we are teaching well and what we are failing to teach, based on students' needs and professional activities beyond the classroom. Much could be handled through individual department surveys of visiting boards and recent graduates, and by using surveys already given out by co-op offices. If these surveys could have some uniformity, the results from different departments and institutions could be combined and shared, which would truly add to our knowledge and help shape our collaborative responses.

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