Responding to changing communication practices: Engineering better technical communications

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Introduction

For both engineering students and non-engineers, writing and communication are generally not considered the top tasks in an engineers' day. However, engineers in academia and industry alike spend anywhere from 30-95% of their days communicating textually and orally, through meetings, emails, phone calls, grant proposals, technical and feasibility reports, and more.[1,2,3,4] Writing and communicating are essential parts of engineering work and advancement, but it's often the part of the engineering process we spend the least amount of time thinking and talking about. Not unlike students, some engineers dread writing so much that they are paralyzed, unable to act on writing tasks until an imminent deadline motivates them. As a result, engineering curricula may not explicitly discuss and teach the appropriate writing and communication skills required for success, and engineering students may develop a false sense of the role that writing and communication play in the daily life of a professional engineer.

In this work-in-progress, we will compare expectations of effective technical communication in engineering classrooms versus those that new engineers encounter as they enter the workforce. Specifically, we review the disconnect between how expectations about effective tech comm are articulated and valued in engineering courses (via assignments' evaluation weighting for communication components, lecture content and duration, writing-focused in-class activities, and other pedagogical methods) and how these same strategies for effective technical communication are valued and weighted by professional engineers. Then we explore ways in which engineering

faculty and classrooms may better prepare students for the communication tasks and requirements they will face outside of the classroom. Finally, we including a brief discussion of the development of a faculty-centered Writing Institute, which would help faculty identify their own writing goals, challenges, and processes as well as explore how our curricula can better reflect the writing and communication expectations and needs of the professional engineering workplaces.

Technical communications of practicing engineers

The average engineering student would likely rank technical skills as more important for engineers than communication and other soft skills. However, engineers do not work alone but in teams of all sizes with both engineers and non-engineers, and communication skills—not technical skills—are what ensure those teams function and are effective. For example, Google's Project Aristotle set out to understand how to create the most effective and productive teams possible, and they discovered that the most successful teams featured members who had strong soft skills including interpersonal communication, critical thinking, and mental flexibility.[5] Of course technical skills are necessary to be a successful engineer, but without the requisite interpersonal and communication skills even the most competent technical engineer will not be successful in the long term.

It's not just tech companies that value communication skills, including writing. In a 2006 survey of over 1600 employers of varying sizes, locations, and disciplines, employers indicated that they value the communications outcomes more than the technical outcomes listed in ABET's Criterion 3.[6] Technical skills are important, but new engineers spend approximately 64% of their work time communicating orally and textually, whether internally on teams and with coworkers or externally with clients and other stakeholders.[2] If a new engineer has poor or ineffective communication skills and does not understand how to identify and communicate about the "economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability"[7] constraints and impacts of engineering, then industry is putting resources into engineers who are unlikely to advance professionally and who may cause liability issues due to ineffective communication.[2,1, 8]

One of the biggest challenges of education is providing students with assignments that reflect the types of intellectual work they will be expected to do in the workplace and other contexts outside of the classroom. In academic spaces, assignments and learning and education outcomes are often based on state and federal educational standards and requirements and assumptions of what students will be asked to do in their careers; in many cases this means the top skills that employers want and need in their new engineers are not an explicit part of the intellectual work of courses.

To better understand technical communications needs and expectations in practicing engineering contexts, Conrad (2017) turned to practicing professionals to identify and define the components of successful technical writing and communications.[1] Conrad found that the industry's top needs for technical communications are not unique to engineering. They reflect what is considered to be strong technical communication in almost any context: concision, directness, precision, and logical organization.[1, 3, 8] For practitioners, these qualities and practices are directly tied to engineering practice, so it becomes obvious how and why every step of the engineering process hinges on rhetorically-aware and rhetorically-responsive communication.[9] Students in classrooms are often not explicitly taught that analysis of audience and purpose are necessary steps in communication processes and required for producing effective products, designs, or processes, yet this type of work is central to effective engineering practice in the workplace.

What does the disconnect about effective tech comm between professional engineers and students look like?

Although there is agreement that good technical communication is concise, precise, well-organized, and direct, these terms are not defined universally across all academic disciplines; additionally, academics who teach technical communication rarely engage with industry professionals to better understand how those terms are understood and engaged in engineering practice.[1,3] Although many studies have demonstrated the importance of communication skills in professional engineering practice, few have examined in detail the professional writing practices and expectations of professional engineers in comparison with the writing practices and beliefs of engineering students. However, Conrad and colleagues gives us a solid foundation on which to begin a productive exploration of the differences in communicative expectations and production of these two groups.

According to industry professionals' definitions of good communication, students are less adept at producing effective technical communication than practicing engineers.[3, 1] Student writing demonstrates a significantly higher incidence of imprecise word choice, wordy and complex sentences, and mechanical and grammatical issues of all kinds.[1] Student errors are also more likely to negatively influence their writing's communicative success: student writing often contains errors that can create ambiguity or misrepresent data or recommendations.[1] In contrast, professional engineers still make errors, they produce fewer overall and fewer that influence meaning, largely because they understand that spelling and punctuation errors can affect their professional credibility and company's liability.

Research suggests many discrepancies between the writing qualities of students versus professional engineers are based on students' misconceptions and mistaken beliefs about what constitutes effective writing. For example, in interviews, students frequently expressed the belief

that vague and imprecise phrasing and word choice would protect them and the company from liability; in contrast, industry professionals argued that those features increased liability for the company, and that specific, precise word choices and clear, direct sentences decreased liability and enhanced clarity.[1,3] Similarly, students displayed mistaken conceptions about sentence structures: students privileged complex sentences, which were often also ambiguously worded, or which expressed unclear relationships.[1] Students intentionally adopted this style because they believed that more complicated sentences enhanced their credibility, and would increase readers' perceptions that they were experts. These beliefs contradicted professional engineers, who argued that concise, simply sentences were easier for clients to understand, and were less likely to be interpreted in multiple or ambiguous ways, resulting in greater credibility and demonstration of expertise.[1]

Research suggests that mechanical errors, imprecise wording, and overly complex sentence structures can all be traced back to students' misconceptions about the effects certain written features have on successful communication in professional engineering situations. Part of this issue is how we weight features of writing in evaluation of student work; for example, Conrad notes that lab reports with low and high incidence of errors both frequently receive grades higher than 90% (p. 206).[1] Students motivated by grades are unlikely to study mechanics and grammar on their own if it isn't helping them achieve their academic goals.

In addition, the persistence of misconceptions about writing suggests that engineering educators in all disciplines ought to emphasize the significance of writing and verbal communication in the work of professional engineers. We should also be discussing and instructing students in the particular features of successful technical communication, ideally within assignments that can illustrate what these features *do* in discipline-specific professional scenarios. Since many of these misconceptions arise because students lack the social context to understand how their writing operates professionally, part of the work of the classroom should be to situate writing tasks with contexts that help address those misconceptions.

Research suggests that industry professionals perceive writing of new hires to be inadequate because, in part: "communication assignments that engineering students perform in college significantly differ from the writing situations (audiences, purposes, and occasions) that engineering graduates encounter in industry" (p. 22.1687.2).[10] To succeed professionally, emerging engineers must learn to produce and value these particular writing features; despite this dependence, these features of successful technical writing are not often explicitly taught to students. According to Donnell (2011), this often happens because instructors in the engineering disciplines lack the knowledge needed to provide students with instruction in both the technical content and communication; this problem is compounded by the fact that students are typically suspicious of feedback from writing instructors who aren't trained in engineering fields.[10] As a

result, engineers are left to learn how to communicate on the fly as they simultaneously adapt to the demands of their first workplace experiences.

What's happening in engineering and technical communications classrooms?

Ultimately, engineers and engineering students have fundamentally different understandings of the centrality of writing in engineering practice.[3]. Though engineering students are told that writing is important for engineers, instruction and assignments often do not reflect this importance, providing a false sense of writing's and communciation's role in the life of an engineer.[8,10,3, 11] The biggest issues in engineering and engineering technical communications classrooms include use of examples as templates; decontextualized assignments without a clear audience or purpose; a lack of scaffolding and details about requirements and expectations for different genres of writing; and lack of rhetorical focus. Overall, the value and role of technical communications in a professional engineer's life is not reflected in engineering classrooms.

Many issues in student writing stem from confusion about genre, purpose, and audience expectations.[3, 1] Decontextualized assignments without a clear audience or purpose beyond writing for an instructor and an over-reliance on models encourage students and engineering faculty alike to understand technical communications as being about format rather than meeting the needs and expectations of the rhetorical situation.[8,10,3,11] Rather than using examples to guide practice, students and instructors treat them as templates to be filled-in. When writing and other communications are stripped of their important rhetorical contexts and functions such as audience and purpose, students are encouraged to go through the motions of completing an assignment rather than developing rhetorically responsive communication that meets the needs and expectations of the genre, audience, and purpose.[3] Further, decontextualized assignments and templates impact students' abilities to both compose useful documents and to transfer their knowledge and learning from the classroom to other contexts.[11,10]

In many cases, students' confusion seems to come back to the ways in which the assignments were introduced, framed, and scaffolded by instructors.[3] For example, the organization in student memos examined by Conrad, Pfeiffer, and Szymoniak were nonlinear and non-strategic in organization. When students were asked about their process and reasoning for their organization, they indicated that they were unsure what details should be included and what a common organizational structure was for that type of document.[3] While professional civil engineers organize recommendation memos "logically," by the sequence practitioners follow in "the process of engineering," students lack this guiding rhetorical context.[1] In other words, instructors may assume that students inherently know (or can deduce by studying a model) the standard rhetorical moves one makes in a particular genre (e.g. recommendation memo), but studies of student work indicates that these rhetorical moves and organization must be an explicit part of

the instructions and framing for the assignment.[3,11,9] Without explicit instruction on genre needs and expectations, audience, and purpose, students will rely on the types of writing they have done in the past such as essays, short answers, and lab memos, none of which reflect the types of writing expected in engineering practice.

Instruction explicitly centered on a rhetorical approach to writing would go far to ameliorate many of the disconnections between student work and expectations and the work and expectations of practicing engineers.[11,9] One potential challenge to a rhetorical approach is engineering's professional commitment to objectivity and the ways in which that commitment to objectivity is instilled in students.[8] Leydens (2009) notes that non-design engineering courses explicitly and implicitly "devalue the open-ended and rhetorically situated nature of design and technical work through the engineering problem-solving approach" (p. 244)[8] that ignores the central role of persuasion and audience in engineering work. Similar to the ways in which professional writing erases evidence of the process used to draft, engineering's successful use of rhetoric often means erasing evidence of its use,[8] providing an inaccurate sense of rhetoric's role in engineering practice.

Though students may acknowledge the role that purpose, audience, and persuasion play during the creation of a product or document, many are reluctant to acknowledge or recognize the ways in which purpose, audience, and persuasion functions in their own work, even when explicitly discussing rhetorical or persuasive components.[8] Instead, students present their technical communications as arhetorical, providing only facts and information which ignores the range of rhetorical decisions made by themselves, by researchers, by publishers, and by funding agencies that all shape who, what, where, when, and why certain projects are developed, promoted, or instituted.[8,9] Further, when students approach technical communications as arhetorical, they can struggle to meet the needs of engineering technical communications and expectations of engineering work: identifying multiple solutions in order to develop the best possible solution and making a recommendation for solving the problem.[3,8]

Further, an arhetorical, template-based approach to engineering technical communications obfuscates the social, political, economic, and cultural concerns that impact engineering practice, including what problems are acknowledged and addressed, what solutions are provided, and what products are developed.[8,9] The effect is both a dehumanizing of engineering work and a misunderstanding of the role that communication plays in successful engineering practice.[9] Effective engineering must be necessarily tied to broader socio-cultural-political contexts. Poor technical communications in engineering can have serious consequences, from lawsuits to injury and death, and certain poor practices may impact the ability to uphold ethical codes.[3,9] Writing in engineering classrooms needs to work to socialize students into engineering contexts,[4] helping them develop tools to engage with and be successful within engineering discourse communities,

and this necessarily means taking a rhetorical view and approach to engineering technical communications in practice and in the classroom.

Our Research Questions

Where does this leave us? Conrad (2017) provides us with some important insights from civil engineering that begin to document the writing qualities that professional engineers most value--directness, precision, standard spelling/grammar, and organization--as well as how those qualities are implemented in writing at a micro-level. We also understand some of the ways that students develop misconceptions about what constitutes successful writing: primarily through pedagogical silences about the professional contexts in which technical communication circulates and functions. Teaching writing without meaningful reference to how it performs its purposes by balancing a variety of factors in a professional setting will only exacerbate engineering students' perceptions that writing is a task separate from what engineers do. If, as Winsor (1996) suggests "a novice has to learn to perceive and react to the world as expert writers do" (p. 168), then we must develop methods to teach writing within scenarios that activate students' understanding of how writing influences their ability to perform their job functions.

Conrad et al. (2015) have demonstrated the benefits of collaboration among industry professionals, linguists, and academics in developing teaching materials to enhance student writing quality and address misconceptions about its significance.[12] Although Conrad et al.'s study provides a useful starting place, more research is needed into the kinds of writing that is done in a variety of engineering disciplines, since, as is documented elsewhere, writing is more important in some engineering disciplines than others (Conrad et al., 2012). We are left with the following questions:

1. In which engineering disciplines do practicing engineers write the most? What writing used for in these disciplines?
2. What are the qualities and characteristics of effective writing in those disciplines, according to industry practitioners?
3. What are the qualities of the teaching methods and materials most effective for helping students master the traits of effective writing and understand their value?
4. What are the most effective teaching methods and materials that help activate students' understanding of the rhetorical professional situations in which their writing is circulated and functions?
5. How can we, as engineering educators in the disciplines, and technical communication experts in stand-alone courses, best collaborate to enhance teaching practices and materials in our own classes?

Small-scale and large-scale surveys

There are multiple ways to answer these questions, both on an individual institutional level and broader disciplinary level. For example, targeted, longitudinal studies about writing and communications needs in upper-division engineering major coursework, internships and co-ops, and employers would provide a better sense of the skills required for engineering practice over time.[10] This would include surveying faculty teaching upper-division courses in engineering, supervisors and team leaders at co-op and internship locations as well as common employers of recently graduated engineers and the new engineers themselves. Many co-ops, universities, and professional organizations already have similar surveys already in place.[10] Creating a uniform survey based on these surveys could help us understand what is being taught and taught well, what isn't being taught (or isn't being taught well), and college, university, employer, and student perceptions of needed skills could help provide a larger, more national understanding of what effective communications in engineering looks like. This process also could potentially identify best practices for integrating and teaching writing and communications to engineering students across contexts.

Faculty Writing Institute

Though surveys would provide the pulse of the issue, we also need to focus on engineering faculty and their relationship to their own writing and communication practices and needs. Helping faculty better understand their own writing and communication processes, roadblocks, and needs can help them develop more useful assignments for their students as well as more easily see the types of scaffolding and framework necessary for composing effective, rhetorically-responsive documents.

An intensive, week-long Writing Institute would assist engineering faculty in understanding their own writing process, including best practices for giving and receiving feedback and identifying appropriate genres and composing rhetorically-responsive texts for different purposes and audiences. Importantly, participants would extensively write and speak publicly about their research and pedagogies. Part of the workshop would include sessions centered on particular types of writing and communication such as NSF and other funding proposals, lightning talks, and public communication. Participants would spend time on metacognitive reflections geared toward understanding their own perceptions and misperceptions of their own writing processes and those of their students, and how they might transfer the skills and knowledge from the institute to their own classrooms.

Conclusion

We need stronger understanding of what kinds of writing and communication professional engineers are being asked to produce to help us better evaluate whether what we're doing is

appropriately working to help students when they become new engineers. New engineers argue that communication is important, that it should be a required class, and that tech comm should be integrated into the technical disciplines more.[2] However, what professional engineers are producing, and what they expect is not crystal clear to academics,[11] and so we need more studies that examine the writing professional engineers produce so we can better design our own assignments and materials that will help our new graduates write better on the job. Answering these questions should help us create materials that better allow us to instruct students in the skills they need, both in disciplinary courses as well as in stand-alone tech comm classes.

It is crucial, though, that writing and communications instruction become a core component of engineering education if we endeavor to produce new engineers who can easily and quickly transfer their classroom experiences to the workplace and field. Conrad, Pfieffer, & Syzmoniak (2012) note that engineering skills take time to develop and writing and communication skills are no different. They argue:

> Writing effectively requires skills and judgement, and these skills and judgement take just as long to develop as other engineering skills and judgment...We would not expect students to take only math and science courses, and then make the jump to using those skills in engineering once they are in workplace. In the same way, we should not expect students to take composition or general technical writing courses, and make the jump to using wiring skill in the ...engineering workplace. Rather...engineering courses need to take an active role in developing writing expertise that reflects values within...engineering practice, including precision, accuracy, consistency, and professionalism. (p. 25.1060.17-18)[3]

In other words, we must apply the same time, attention, and care used to teach students technical engineering skills to teach rhetorically-based communications to students. If engineering educators do not explicitly demonstrate and reinforce the importance of rhetoric in engineering processes through our courses and assignments, new engineers will continue to struggle to meet the communications needs and expectations of engineering practice.

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