A PRELIMINARY REVIEW OF COMMUNICATION INSTRUCTION IN AN INTERNATIONAL UNDERGRADUATE ENGINEERING CONTEXT

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ABSTRACT

In this international study, we attempt to update previous research on engineering curricula that integrate communication instruction in order to explore four hypotheses: 1) where and how many institutions are involved in this work, 2) what theoretical frameworks of communication are taught or pedagogically practiced, 3) whether communication activities are supported with instruction, and 4) whether such integrative curricular efforts are assessed. Our preliminary research has identified 20 institutions that employ authentic integration of communication in the engineering curriculum. We endorse Reave's definition of authentic integration as the collaboration between instructors, in which at least one has technical expertise and another has communication expertise, to engage engineering students in a meaningfully unified course or project. Having identified four main findings within the literature, we attempt to outline a descriptive framework for researching the authentic integration of communication in the engineering curricula. These efforts are an attempt to map the field of engineering communication as it has evolved over approximately the last three and a half decades. In the next stages of this project, we hope to highlight institutions and models for integrating communication in the engineering curricula as well as provide insights and practical methods for launching or strengthening efforts at institutions worldwide.

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1 INTRODUCTION

Communication is ubiquitous in the lives of professional engineers. In their attempt “to establish a comprehensive list of generic engineering competencies … [and] their relative importance,” Passow and Passow identified the ability to communicate effectively as one of the most important competencies [1]. Indeed, because communication is both a ubiquitous and indispensable competency, Paretti et al. provide “guidelines” for introducing communication within engineering disciplines [2]. However, little is known about whether these guidelines have been adopted; for example, very few higher education institutions offer communication instruction “within engineering units” [3]. Our research so far confirms this assertion.

We are in the preliminary stage of a two-year study in which we will complete a systematic and international literature review of pedagogical practices for offering communication instruction in undergraduate engineering curricula. Our goal is two-fold. First, we expect to identify the “status quo,” or to answer the question: what are the most common features or characteristics of engineering curricula concerning engineering communication and communication instruction? Second, we expect to identify innovative engineering curricula, curricula that have found theory-based and pedagogically-sound ways of integrating engineering communication practice in concert with instruction and to share those innovations more generally.

Even at this preliminary stage, one observation is conspicuous: All the stakeholders in engineering education (with the possible exception only of novice engineering students) consider communication extremely important both for participation and advancement in the field. There is no better way to articulate this importance than to quote the MIT Writing Across the Curriculum Program – “Engineers who don’t write well end up working for engineers who do write well” [4]. Our early results indicate:

1. communication instruction is too often completely absent from engineering curricula;
2. when communication instruction is integrated in engineering curricula, there is rarely an articulated theoretical framework for understanding communication that informs instruction;
3. when communication assignments are given, many engineering faculty use those assignments as ways to facilitate learning engineering—there is little actual instruction about how to communicate; and
4. there is no valid or reliable assessment protocol that is generalizable across a single curriculum or across engineering educational curricula.

Based upon these results, we argue that, if there is an interest in integrating communications practice and instruction into engineering curricula (and given the widespread affirmation of its importance, we believe there should be interest), then articulating a theoretical framework for understanding communication, providing instruction about how to communicate, and creating a valid and reliable assessment tool are essential.

2 METHODOLOGY

Ours is a daunting undertaking. Importantly, engineering communication as distinct but not wholly separate from technical communication or science communication seems to have arrived only recently in the literature [2]. Paretti et al. further acknowledge that what "is called writing (communication) in the disciplines" or WID (CID) in the US is referred to as "integrating content and language (ICL)" or "content and language integrated learning (CLIL)" in Europe [3, p. 27]. Finally, there are references in the literature to communication in a number of different contexts with different purposes related to each, e.g., communication in teams and interpersonal communication.

In this preliminary stage of the study, we conducted a search of the relevant literature using the keyword "engineering communication" and traced the citation patterns of literature that we established were integral to the Engineering Communications Program at Cornell University [2], [5], [6]. From there, we identified a cluster of over 20 articles in scholarly conversation with one another via citation practices (see Figure 1). Our aim was to establish what Miles and Huberman [7] refer to as a descriptive framework.

Fig 1. Cluster Diagram of Over 20 Articles Cited in this Review. Green bubbles represent national programs and purple bubbles represent international programs (Finding 1); light red bubbles represent theoretical frameworks (Finding 2); the hot pink bubble represents assignments not instruction (Finding 3); and light blue bubbles represent assessment protocols (Finding 4).

Establishing a descriptive framework as a preliminary is both very important, especially with new research projects, and, unfortunately, often neglected, not considered real research. However, developing such a framework involves a number of critical steps. Researchers must determine what phenomenon they hope to study. We are studying the integration of communication practices and instruction into engineering curricula. They must formulate research questions or hypotheses. Our questions are stated above. They need to cull out their informed intuitions concerning that phenomenon. Our informed intuitions are stated in our early results. And finally, researchers need, in a prefatory way, to consult related research. They need to review the contributions of that research and, based on those contributions, select a methodology and methods that are likely to provide answers. Our methodology and methods for continuing the next stages of this project are provided in the discussion section.

In the results that follow, our paper offers that descriptive framework. We consider it to be both foundational and crucial for the credibility of our future findings.

3 RESULTS OF THIS LITERATURE REVIEW

In this section, we share examples both from literature and our own investigations of communication programs embedded within engineering colleges or departments. To date, Reave conducted the most thorough survey of the 73 top-ranked engineering schools in the US and Canada [6]. Over the next two years, our aim with this overall study is to update and expand upon Reave's efforts.

3.1 Finding 1: Few Engineering Curricula Integrate Communication Instruction

In the most expansive research thus far, Reave found that only 50% of schools "required a course in technical communication" [6]. The percentage was better for Canada – 80% [6]. However, only 33% of US and Canadian schools offered "some form of integrated communication instruction," or roughly 24 institutions [6]. In addition, only 10 schools had "created engineering communication centers" [6, p. 453] to offer supplemental and situational instruction.

Our research and experience shows multiple methods of uniting communication instruction and engineering curricula. The least common method is to integrate communication practice and instruction across the entire engineering curriculum. We have only located three such programs so far [8]–[10]. MIT is particularly unique in that *all* students, regardless of major, take two communication intensive (CI) classes, and two "CI classes in the majors [that] emphasize communication in the learning of disciplinary content and are taught collaboratively by technical and writing faculty" [10, p. 280]. Another unique program exists at Rice University [11]. The second most common are departments or units that integrate communication practice and instruction across their specific disciplinary or major offerings. So far, we have identified 16 national [5], [10]–[21] and 4 international institutions [9], [22]–[24] implementing this model. Yet more common still are schools and colleges of engineering that outsource communication practice and instruction, sending their students to other departments to take a technical and/or professional communication service course. Most common are schools of engineering that do nothing at all [6].

Throughout the literature, the word *integration* signals a shift in the model of including communication instruction in engineering curricula. We align our definition of this model with Reave, who specifies that *authentic integration* is when “a communication instructor participated in the engineering course” [6, p. 463]. As far back as 1987, Youra noted, “the most substantial approach to communications instruction actually integrates writing and speech exercises into subject-matter courses” [25, pp. 410–411]. Besides the European model for engineering communication (ICL) explicitly using *integrating* in its key term, at least nine national and international pieces of scholarship use this word in their titles [13], [14], [16], [18], [22], [24], [26]–[28]. Therefore, we have reason to believe that an integration model that blends both communication and engineering instructors’ expertise has taken a foothold in both national and international engineering curricula for roughly the past 34 years.

The most common model relies upon service courses offered by English departments and/or technical and professional communication programs. Historically, in the mid-1940s, both English and engineering faculty denigrated these service courses: “neither freshman composition nor technical writing courses were claimed or championed by either side” [29, p. 12]. In fact, these courses were mostly taught by graduate students and adjunct instructors [29, p. 14]. To read between the lines, faculty did not want to teach courses to students who they presupposed could not write well. Perhaps this stereotype has led to the current situation, and as Berdanier recently explains, “Few engineering education scholars conduct theory-driven investigations of engineering writing processes and artifacts” [30, p. 378].

3.2 Finding 2: Engineering Curricula Often Neglect a Theoretical Communication Framework

Of the network of literature in this review, two pieces stood out as the most foundational to studying how communication instruction is situated pedagogically and theoretically within engineering curricula: Artemeva et al. [31] and Winsor [32]. Artemeva et al.’s work developed a sound framework for the authentic integration of engineering communication based upon genre theory and situated learning. Primarily, the authors explain how the theoretical concepts of Miller’s genre as social action, Austin’s “do[ing] things with words,” and Swales’s discourse communities help students to develop the rhetorical skills necessary for engineering work [31, pp. 304–305]. In terms of pedagogy, Artemeva et al. argue that engineering students learn best from Hunt’s notion of adopting real contexts for their work and by “explor[ing] and respond[ing] to the rhetorical situations (Bitzer) in which they function as engineering students” [31, p. 304]. The authors also draw heavily upon Winsor’s influential book, *Writing Like an Engineer: A Rhetorical Education* [32].

Our evidence for claiming the foundational nature of Artemeva et al. and Winsor’s work lies in mapping citation patterns and practices. In terms of how we categorized the literature in this review, 8 articles related to Finding 1 [5], [14], [16]–[18], [22], [23], [33], and 4 articles related to Finding 2 [30], [34]–[36] cited Artemeva et al. The literature in this review cited Winsor nearly as often with 6 articles related to Finding 1 [3], [5], [12], [16], [26], [33], 3 articles related to Finding 2 [2], [31], [35], and 1 article related to Finding 3 [37]. However, when it came to the original theoretical and pedagogical frameworks, the citation patterns we traced revealed far fewer references to authors such as Miller, Swales, Vygotsky, and Gee. By our analysis, the citation patterns indicated that much of the scholarship on the authentic integration model is one step removed from the original theories which carefully and intentionally frame engineering communication instruction. The reason this finding concerns us is that those constructing integrated engineering communication programs are less aware of the implications of those underlying, original communication theories.

We stated that [2] was quite fundamental to the Engineering Communications Program at Cornell University, largely because we cultivated our program upon the theoretical constructs the authors cite. Specifically, we also endorse genre as social action [38], the sociocultural nature of learning by interacting [39], a semiotic or multiliteracy approach to communication [40], discourse communities, and situated learning in engineering courses [4]. While some scholarship attempts to theorize how and why the authentic integration model of engineering communication is worthwhile [2], [30], [31], [34]–[36],—particularly Paretti’s extensive body of work—we predict that as we expand this search, citation patterns may continue to stay somewhat removed from sources of theory and pedagogy. We suspect this is the case due to the multidisciplinary nature of communication integration.

In some ways, this finding is literally “nothing new,” as the same theory of deficiency has been espoused about engineers’ writing for over a century. As [41] summarized, “In the early 1900s, engineering journals and weeklies ‘decried’ new engineers’ writing (Connors, p. 5), even going so far as to call it ‘wretched’ (p. 6)” [p. 9]. More recently, a national survey of undergraduate engineering professors reported that only 22% were satisfied with their students’ writing abilities [37]. Not only are professors disappointed, but also employers. A study of managers’ satisfaction with engineering graduates in the Middle East and North Africa region found that while speaking clearly was one of the top three most important skills, “Communication skills [...] represented an area where managers felt graduates needed great improvement” [42, p. 46]. For over a century, newly minted engineers have been described both anecdotally and empirically as lacking critical writing and communication skills.

3.3 Finding 3: Engineering Curricula Include Communication Assignments but not Actual Instruction

Research shows that while engineering faculty often assign communicative work [6], [37], there is little to no instruction in how to communicate in particular genres or how theories of communication should be applied to this work. According to different surveys, as few as 66% of engineering faculty [37] and as many as 82% [43, p. 15] assign written work. Reave summarizes this situation best: “requiring performance is not the same thing as providing instruction” [6, p. 464]. Here we attempt to explain common reasons why assignments or “performance” are more common than integrated instruction.

Williams may have been the first to state the most fundamental challenge associated with communications in an engineering curriculum [5]. Engineering faculty and professionals are aware of the genres and conventions for communicating in their discipline/field. However, they are not aware of how to teach those genres and conventions. Consequently, they are “disinclined or unable” to teach them [5]. Engineering communication professionals, on the other hand, do understand communication pedagogy and the need for communication practice and instruction. However, as outsiders to the profession of engineering, they are not familiar with the genres or conventions for communication in engineering, even less so with how those genres and conventions vary according to discipline. This challenge was echoed years later when Paretti and McNair identified this as an “issue of expertise” [44]. More optimistically stated, it is an opportunity for interdisciplinarity and teaching partnerships.

Additional challenges include the amount of technical learning outcomes and enrollment numbers in engineering courses. Engineering curricula must reflect an “ever-expanding technical knowledge base” [44]. Therefore, finding room for communication practice and instruction is arduous. In order for students to learn how to communicate, they must be given opportunities to practice and receive instruction. Creating assignments, providing instruction, giving feedback and grading are very labor-intensive. Considering the heavy workload of engineering faculty already, adding to their workload is not viable. A compounding factor is that in many schools and colleges of engineering, class enrollments are large, making integrating communication practice and instruction almost impossible [37].

3.4 Finding 4: No Existing Assessment Protocol for Communication Instruction in Engineering Curricula

There is no valid or reliable assessment protocol that is generalizable across a single curriculum or across engineering educational curricula. Yong and Ashman [24] indirectly point to the reason. In their struggle to find a good assessment method for their integrated curriculum, they use grades and student evaluations to assess whether or not the students’ learning was positively affected [24]. Neither grades nor evaluations would be considered valid or reliable assessments across curricula or even across a single curriculum because they evaluate from a one-way perspective. An assessment is a research endeavor that is recursive and generative of new knowledge.

Portfolios seem the most likely candidate for assessment of CID, CAC, and ICL efforts. However, Williams, in her attempt to facilitate the use of portfolios, highlights just the problems that prevent their use [45]. She makes an important distinction early on concerning “individual student assessment and program assessment” [45]. In terms of individual student assessment, portfolios have a long and proud history. They encourage student reflection and reflexion. They focus instructor evaluation on situated performance. And, they facilitate the general understanding of communication as a part of and not apart from engineering practice. It is when portfolios are used for program assessment that the difficulties arise.

Williams identifies four principles for the use of portfolios for program assessment: 1) defining engineering communication, 2) identifying appropriate skills, 3) correlating portfolio objectives across the curriculum, and 4) assessing so that students, faculty, and programs improve [45]. First, while faculty may be quite accomplished communicators in engineering academic venues; they are engineers, not communication specialists who have studied communication generally and engineering communication specifically. As a result, arriving at a single theoretically-sound definition of engineering communication is unlikely. A worst outcome would be employing a definition that is theoretically misguided or just wrong. Engineering faculty are aware of the limits of their own expertise; therefore, asking those faculty to define engineering communication is a bridge too far. Second, identifying appropriate skills is always context dependent. The communications skills necessary in one engineering context may and will vary radically from other engineering contexts. Generating rubrics, thereby suggesting the necessary skills, is of course very helpful. However, rarely are those rubrics extended across an entire curriculum. The negotiation between faculty within a department and between departments across a college curriculum make such a rubric another bridge too far. Third, correlating portfolio objectives, like defining engineering communication and creating curricular-wide communication rubrics requires coordination, collaboration, and constant and committed application. In other words, the first two must have occurred and been successful before this third principle can happen. Further, in an academic world where most faculty are not rewarded for such work and believe that that work only serves to “fulfill the accreditation demands of higher powers,” the coordination, collaboration, constant and committed application are yet again a bridge too far [45]. By the way, students will not be particularly happy with all the additional work that they must undertake in a curriculum and curricula that are already extremely challenging. Fourth, assessing so that students, faculty, and programs improve would require an educational research agenda that is truly demanding. Again, engineering faculty are not educational researchers. Students are not research subjects in the sense that we can allow for or tolerate failure. There are a growing number of engineering education programs and departments situated in departments, schools, and colleges. Potentially, they could help. Still, the necessary resources to show near- and long-term improvement are prohibitive. A fourth and final bridge too far.

Williams ends her paper optimistically: “The future … [for engineering portfolios] appears bright, if we can survive the development process” [45]. We suggest that, currently, portfolios as a tool for assessment cannot. There are important outcomes that can be realized with portfolios. Paretti shows that portfolios “can provide actionable information about the extent to which ICL programs foster content and language learning” [27]. These outcomes, however, are most often situated and specific. We have emphasized the obstacles to implementing portfolios as a generalizable, valid and reliable approach to assessment. Any approach must embody each of these characteristics. There is yet another. It must be easy. To date, such an approach does not exist.

4 DISCUSSION

Exploring the four hypotheses we offered at the outset of this paper through a network of literature was a necessary beginning to this study; however, as we proceed, we must expand and complicate this search. Our research project includes three follow-up stages. In stage one, we will systematically search national and international journals of engineering education. We will focus especially on the Journal of Engineering Education, the European Journal of Engineering Education, the International Journal of Engineering Education, the Australasian Journal of Engineering Education and IEEE Transactions on Professional Communication. In stage two, we will follow up with a similar search of conference papers associated with such organizations as ASEE, AAEE, SEFI, FIE, and IEEE ProComm. In the American Society of Engineering Education (ASEE) proceedings alone, there are over 1,700 references to the keyword search of “engineering communication.” Employing methods outlined by Geisler and Swarts [45], we will use corpus data analytics to search for keywords included in this paper to identify relevant papers. After narrowing the data set, we plan to develop a coding scheme based upon the four findings detailed in the following section and systematically code the data in a qualitative analysis software such as NVivo.

Stage three involves the development and distribution of a survey instrument to national and international schools and colleges of engineering. We expect to focus on those schools and colleges integrating communication practice and instruction and will attempt to identify innovative ways to realize that integration. This stage will also include select site visits to those institutions considered innovators in any of the four findings described in the results.

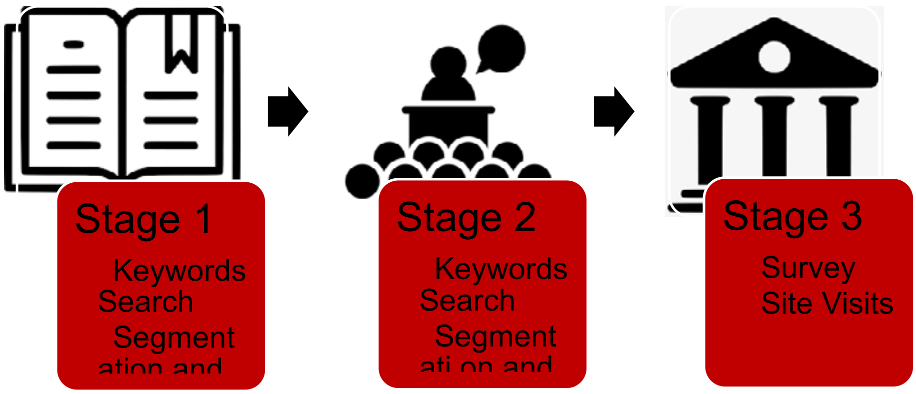

Fig. 2. Diagram of the Three Stages of this Research Project.

Indeed, ours ***is*** a daunting undertaking. Just one of the real challenges that we expect to encounter is schools and colleges engaging in authentic integration, but not publishing or presenting about their approach for or results of that integration. Eventually, we hope to be able to offer a range of possible “models” for the authentic integration of communication practice and instruction that can be fitted to the particular circumstances and situations of engineering curricula.

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