

## **Making the Case for Technical Communication Courses in Ph.D. Engineering Curricula**

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## **Making the Case for Technical Communication Training in Ph.D. Engineering Curricula: focus on international students**

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A substantial and identifiable need exists for Ph.D. engineering students to receive instruction in academic communication genres. The importance of effective communication for individual researchers, for the field, and for promoting the broader impact to society are all recognized benefits, yet opportunities for engineering students, particularly at the doctoral level to develop their communication skills are relatively lacking. Furthermore, the basic realities of doctoral programs make it difficult for students to make use of available resources to help them improve their writing and oral competencies.

This research paper presents results of an exploratory survey of Ph.D. students and identifies several communication-related needs that should be addressed in their programs to enable them to function as independent researchers. The ability to communicate effectively supports engineering Ph.D.'s ability to fully participate in the many communication-related aspects of their scholarly community such as the exchange of ideas, informal and formal collaborations, and collegial interactions. They need communications training to be teachers, to mentor, to write impactful papers and proposals, and to secure academic positions. Such benefits are clear, how they can best be supported through a variety of modes including, course offerings, labs, workshops, one-on-one coaching and instructional platforms needs further investigation.

Specific communication needs of Ph.D. students range from assistance with basic grammatical structures, word choice and other surface-level issues to the clear and precise articulation of complex and abstract research using specialized language and the formalized structures of academic expression. The combination of managing sophisticated scientific material, mingled with a less developed experiential base in terms of using academic rhetorical forms is the situation that many engineering graduate students face.

The high percentage of non-native writers and speakers pursuing Ph.D.'s in engineering presents another layer of needs to address, as these students may have less exposure to academic English instruction, and thus less opportunity to experiment and develop specific academic writing and speaking skills. Academic communication courses, workshops, tutorials and other resources are vital in providing a means to overcome uncertainties, realize a path to improvement, and to develop a scholarly voice.

This paper explores the distinct communication needs of the engineering Ph.D. student which tend to be under-serviced relative to offering for undergraduates, industry-oriented professionals and other technical communication genres. Emphasis is placed on international students who increasingly make up a significant proportion, if not the majority of Ph.D. engineering students in U.S. universities.

Through our exploratory survey and interviews with faculty and students we highlight the characteristics of the engineering Ph.D. student population related to their academic communications, results and benefits from existing academic communication courses, and

finally, impediments and possible solutions to support the growth of resources and most importantly, their utilization.

Findings presented here, based on survey data, interviews and empirical evidence indicate that motivating the development of academic writing and speaking among engineering Ph.D. students requires relevancy to the research field of students. Among other inferences, we see that given the time-strapped situation of most Ph.D. engineering students, instruction that relates closely to in-progress work is meaningful and thus, an anchor to attention and improvement. To improve fluency and flow, in writing and speaking, a topical focus on ethical issues has served to link specialized technical information to broader social communication that ultimately helps connects students to greater communication opportunities.

## **Introduction**

Ph.D. engineering students and faculty alike understand the critical need to communicate effectively in order to lead research projects, teach, mentor, write papers and proposals, and to generally succeed in the world of academia or private industry. This is not a matter of debate, however key questions require more substantive investigation.

A casual review of typical instructional offerings for Ph.D. engineering students at ten major US universities shows that most offer a basic academic writing course and supports for dissertation writing (i.e. sporadic workshops, meetings on a more regular basis, individual coaching, and online resources). Less common is a comprehensive approach of sustained and gradual communication development that begins in addressing first year Ph.D. student needs and continues through the dissertation phase. Also, despite the importance of publication and oral presenting in achieving academic success, required communications courses appear to be a rarity.

The ever-growing need for Ph.D. communication instruction suggests several questions: Are Ph.D. engineering students acquiring the skills they need to succeed in their professional careers, either on their own or through resources in their programs? How in fact have engineering schools responded to the growth of enrollment of foreign students so that graduating students are prepared to successfully lead in their field? What kinds of communication-related offerings are most beneficial: courses, labs, workshops, one-on-one coaching, integration of communication instruction into technical programs? While a number of U.S. institutions offer a range of supports for Ph.D. engineering students, the increasing proportion of foreign students is diverse, thus, insight around these needs is a starting point for developing communication programs that successfully provide value.

## **Literature Review**

Few studies specifically examine the communication needs of graduate engineering students or identify resources and training efforts that address these needs. Nonetheless, academics and practitioners alike seem to agree that engineering graduate students are faced with communication challenges reflective of the complexity of the material that they must disseminate, and thus would benefit from supportive efforts to hone their skills.

Many guides and textbooks are available to help teach the international student population in U.S. universities in general, but less is specifically geared to engineering doctoral students. A range of engineering communication scholarship covering pedagogy, theory and practice are detailed in [1].

Nonetheless, studies that focus on engineering Ph.D. student's communications needs are not yet plentiful [2,3,4,5]. [6] provides an account of experience teaching technical communications using a cross-cultural perspective to aide in understanding of audience and context, and using a case study approach, [7] describes methods to support Ph.D. science and engineering students academic writing competency. A research method utilizing video to study cognitive aspects of the engineering writing process is shown by [8]. In addition, [9] has investigated the writing attitudes and processes of engineering graduate students, and suggests that this type of student may approach writing differently than graduate students in other disciplines, and thus instruction should be developed that best helps them participate in the discourse of their field.

Developing academic literacy is also traced in a case study by [10]. In addition, [11], describe a national workshop to systematically teach Ph.D. students how to communicate engineering and scientific research as an antidote to the typical process of ad hoc student learning from colleagues and advisors. [12] describe the value of adding a component of ethics education to engineering graduate curricula to promote awareness of professional norms in the U.S. and greater awareness of the societal context of engineering. Adding an ethics component to graduate communication courses has supported discourse and motivation to express and experiment with writing and speaking strategies in the classroom. In line with [13], identifying writing projects that students care about, even if they are of a non-technical nature, supports motivation to express. These efforts are bridges that lead students to improvements in their scholarly writing.

Regarding international students, studies have looked at adjustment issues, as well as the social and psychological conditions that are often faced. Perceptions of international students at U.S. institutions has been investigated by [14], as well as factors influencing adjustment by international students to U.S. culture [15,16]. This prior work provides a foundation for developing specific instructional modalities for Ph.D. engineering students.

## **Methodology**

A mixed methods approach has been employed to gather both structured data as well as descriptive, experiential information about Ph.D. engineering student's communications-related challenges and means to address these issues. A few targeted interviews were conducted with faculty at engineering and business schools in the U.S. to help identify useful models. Feedback was solicited from Ph.D. engineering graduate students at a major research university in California to form the basis for needs-assessment and recommendations on beneficial institutional supports to prepare engineering researchers to succeed in the global academic and professional arena. Ph.D. student feedback is based on a student cohort who complete the oral and writing communications classes offered at this university. Students fill out a survey when enter these classes about their motivations, background, strengths and weaknesses. When the

class/classes are complete, they fill out another information sheet that reports on their perceptions of improvement or lack thereof.

In addition, a general survey was distributed to all current Ph.D. engineering students at this same institution. Figures for this California university show that in 2017, 1,015 full time doctoral students were enrolled, and 746 of this number were foreign students. Roughly 90% of survey responders are foreign students: 42% are Chinese speakers, 11% are Hindustani speakers, 8% are Persian speakers, 5% are Korean, speakers, 11% are Spanish speakers, 10% are Farsi speakers and 12% are French speakers from the total of 93 responses. Additional languages represented include Greek, Russian, Indonesian, Tamil, Urdu, among others. While it would be useful to include comparison of U.S.-born students and foreign students, insufficient data on U.S.-born students limits useful analysis in this study. Given that the data on the whole represents international students, we focus on this group, rather than US-born students. Further study that includes U.S.-born students should be pursued, but is outside the parameters of this paper.

Additional characteristics of survey respondents are as follows: 22% have not yet taken screening exams, 22% have passed their screening exam, 31% have not taken the qualifying exam, 10% have passed their qualifying exam, 7% are writing their dissertations, and 4% are ready to defend. In terms of representation of program stages, the survey reflects proportional representation, with 23% of students in their first year, 20% in their second year, 17% in their 3<sup>rd</sup> year, 21% in their 4<sup>th</sup> year, and 20% in their 5<sup>th</sup> year or more. Further, survey respondents reflect various departments within the school of engineering, with the majority of respondents coming from computer science and electrical engineering, the most populous departments, followed by biomedical engineering. When asked about career plans, 42% of respondents hope to find a tenure track academic position, another 26% seek a teaching position at a university, college or other institution, and 76% are considering industry positions.

### **Communities of Practice as a Lens for Viewing Engineering Student's Communication Needs**

The idea of communities of practice have been applied in diverse contexts [17] but can be usefully employed as a lens for understanding the urgent need for Ph.D. graduate engineering students to be equipped with the tools for entering the field of engineering, including academia, industry, or government. Communities of practice in terms of Ph.D. engineering students characterizes entry and engagement with a variety of groups: laboratories, programs, the wider academic field, working groups, informal cooperation, or collaborative projects. Relationships and identities are developed as knowledge is shared and activities progress. The dynamics of such communities is undeniably affected by the communication approaches, styles, and competences of its members. Providing the tools for Ph.D. engineering students to enter and engage in such communities, both face-to-face and virtually, thus requires communication training to support effective socialization.

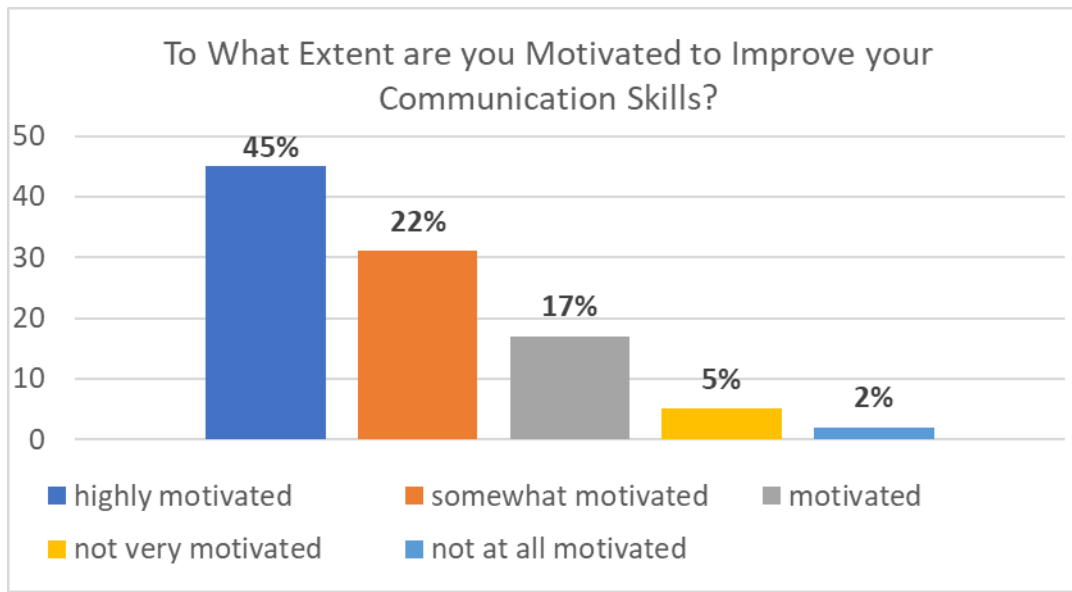
## Identifying Ph.D. Engineering Student's Communications Needs: findings

While our survey results of students indicate a high level of satisfaction among those who took one of the academic writing or speaking classes that is on offer at our university, many students (54%) responded that while they needed help, they didn't feel that they had the time to devote to a course devoted to writing or speaking. Tellingly, the majority of students report that they spend more than 70% of their day communicating in a language other than English. The perception (and reality) is that students find it difficult to fit communications training into their already-full programs. One student remarked, "Still more coursework seems stressful and will take away from my research time." This is a primary obstacle.

Faculty also identify this tension, in acknowledging that their graduate students need help improving their academic writing and speaking, they also do not see how their students can viably take courses to address their weaknesses. Several students report that their advisor's prompting is key in motivating them to improve their competencies and take communication courses. Word of mouth through friends is the primary means that motivate students to take one or both of the communications courses that are offered.

In surveying Ph.D. engineering students, the majority report that they find communication skills to be a significant roadblock to success in their program, and to their social integration in the US system. In open ended comments they express anxiety about their communication skills in regard to the impact on their future career. Consequently, they report a high level of motivation to improve their communication skills as shown below in Figure 1 with 67% of respondents reporting that they are highly motivated or somewhat motivated to improve their communication skills.

Figure 1



% represents respondents' degree of agreement

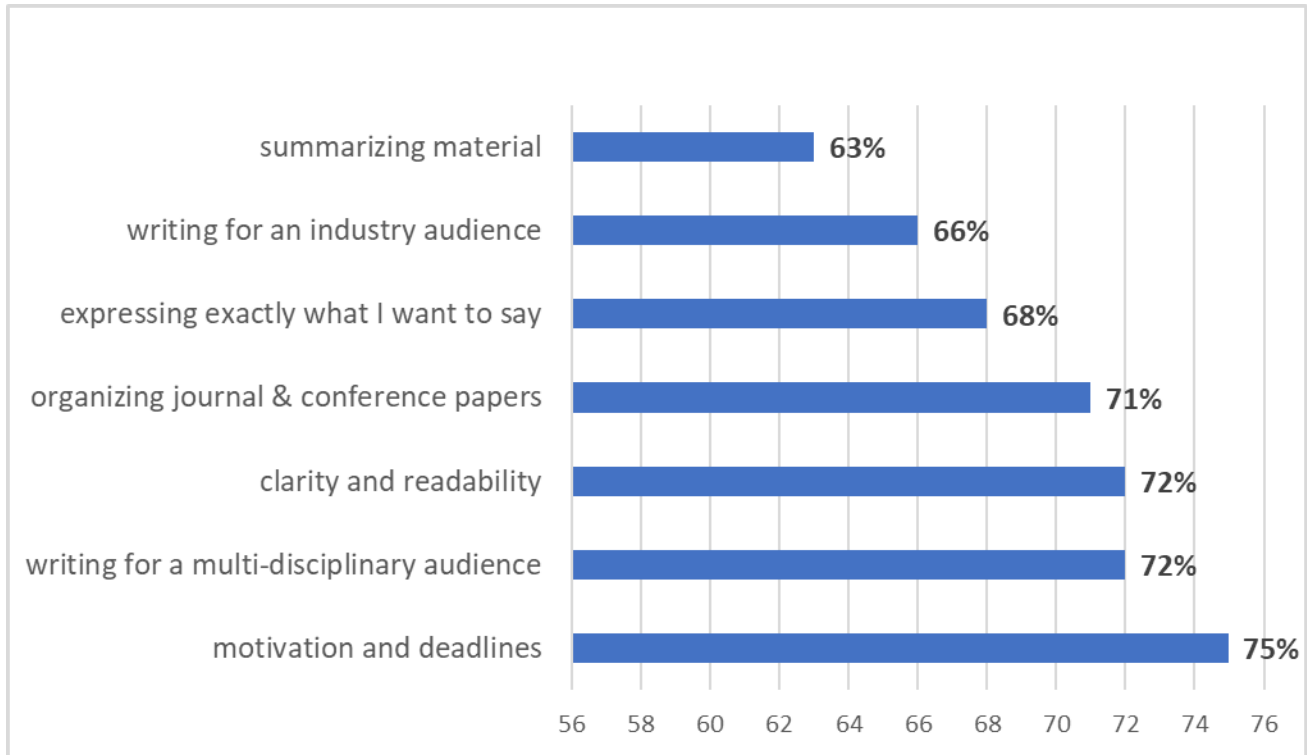
## **The Dark Side of Graduate Student's Perceptions of Improvement Possibilities**

Despite widespread recognition (by faculty and students alike) that problems in communicating represent a significant hurdle to career success, actually taking steps to build these skills appears to be another hurdle. While faculty interviews overwhelmingly acknowledged the criticality of their students having adequate communication abilities to function and excel in their field, worry was expressed that time devoted to writing and speaking courses threatened displacement of time for primary work. The time-crunch argument poses a dilemma for students who recognize their perceived shortcomings, yet don't have the space to tackle this skill gap. When students are asked in the writing course what their major strengths in their writing are, a frequent response is, "No strength. I write badly." Another response, "I am not able to express my thoughts clearly and naturally enough. I realize that I need to improve my writing skills."

As seen below in Figure 2, several basic problem areas were self-identified by students in regard to their writing. Clarity and readability, writing for different audiences, including multi-disciplinary audiences, and "expressing exactly what I want to say," top the list of writing issues. In addition to the items listed below, over 50% of respondents cite general fear and anxiety of writing as a problem, as well as coherence and word choice issues. Using specialized vocabulary of the field surprisingly is not considered an issue – only 9% felt to a great extent that this was a problem. This finding perhaps reflects the fact that Ph.D. students become familiar with the phrasing and language of their field through reading the literature.

Figure 2

What are the Problem Areas in Your Academic Writing?



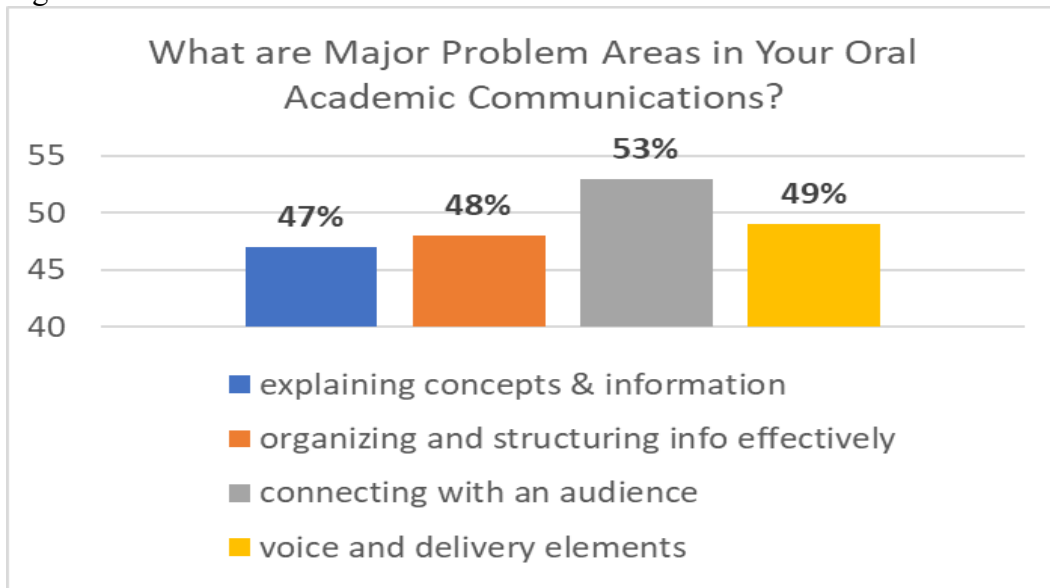
% represents respondents' degree of agreement to a great extent/to some extent

Every variety of professional writing has its own standards and forms to convey information, persuade, engage, transact and fulfill multiple additional purposes. Conventions for engineering writing are an area that students gain immediate experience with through reading journal papers. Organizing material into the form of a journal paper and utilizing the phrasing and vocabulary of their field are manageable for most Ph.D. students since they can rely on existing models. This tactic is helpful, but also has obvious limitations when it comes to communicating new results and discussing them (arguably the more challenging parts of a journal paper for junior scholars).

Figure 3 below indicates some of the areas of difficulty that survey respondents report as problematic in their oral academic communications. Connecting with an audience is considered a major area of difficulty by over 50% of respondents. Vocal and delivery elements, organizing and explaining information were also nearly ranked as high as problem areas. To address this need, the oral communications course works with students individually to help them modulate their vocal range, pitch and pace. This effort is particularly valuable to non-native speakers who report increased confidence and feeling of connection when they speak formally and in more casual conversation.



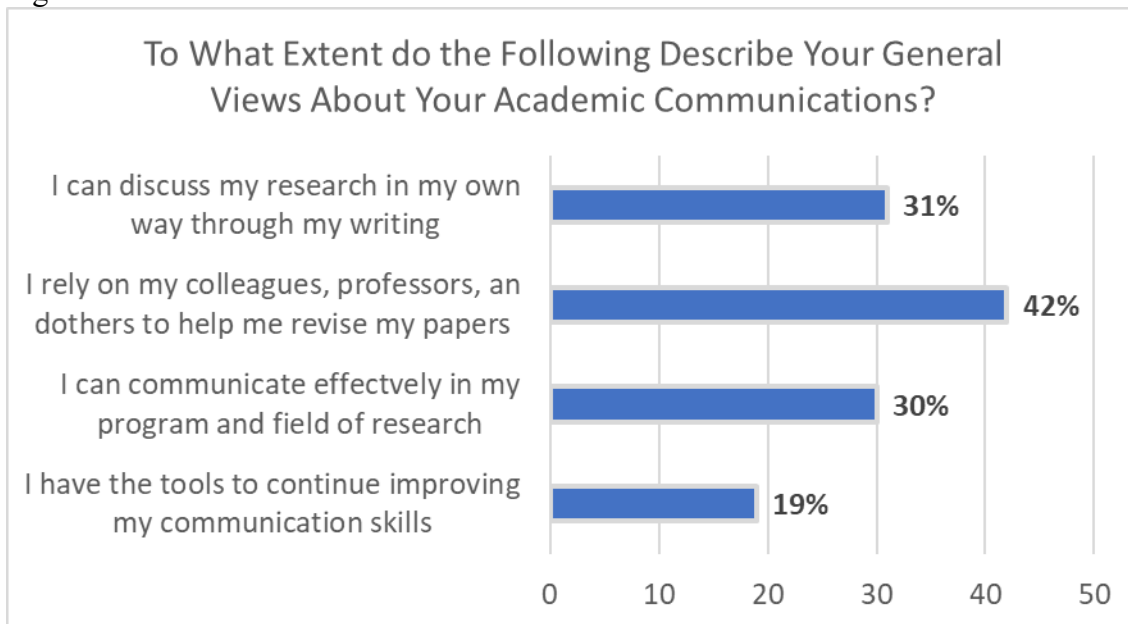
Figure 3



% represents respondents' degree of agreement to a great extent/to some extent

When respondents were asked about their general views surrounding their academic communication abilities, their responses indicate vulnerability. As shown below, in Figure 4 30% feel they can communicate effectively in their program and field of research, and 31% can discuss their research in their own way through their writing. This low level of confidence is matched with a 19% agreement with the statement, "I have the tools to continue improving my communication skills."

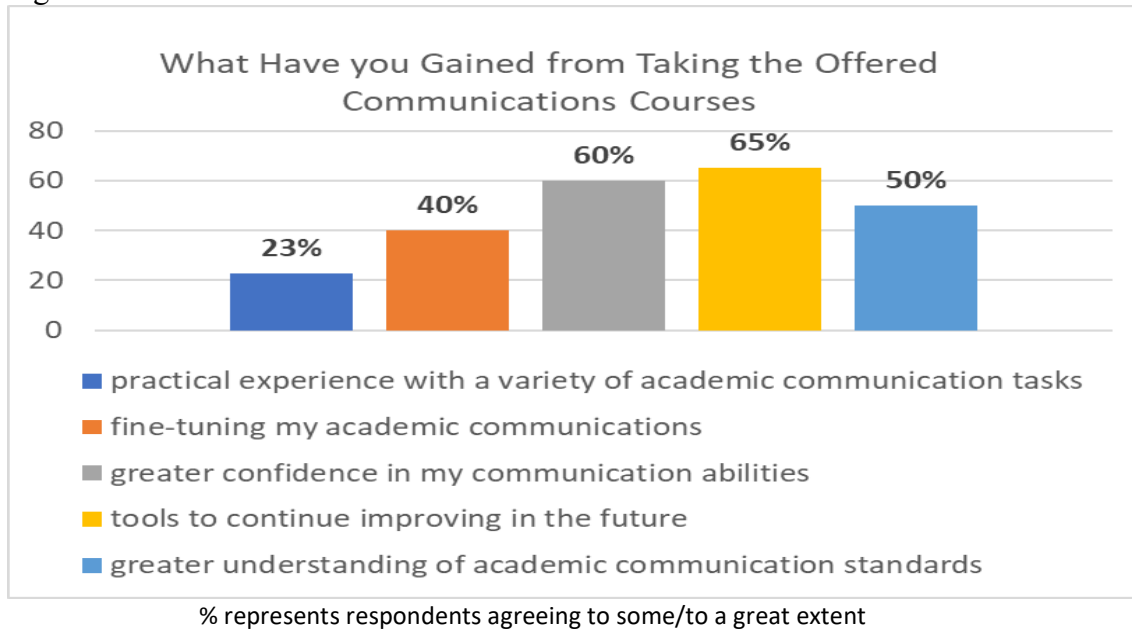
Figure 4



% represents respondents' degree of agreement to a great extent/to some extent

Next, in Figure 5, we see that students report greater confidence in their writing abilities and acquisition of tools for continued improvement among the greatest benefits of taking a graduate communications course. While improvements in writing are usually incremental in the confines of a single communications course, students often report that their attitude towards writing becomes more positive as a result of taking the course which can improve openness to tackling writing in the future and further improvement.

Figure 5



These initial survey findings suggest there is a need for additional institutional support to help Ph.D. students in technical fields to overcome their communication challenges. In the case of international students, these challenges are particularly profound and include language difficulties and acculturation issues that need to be better understood.

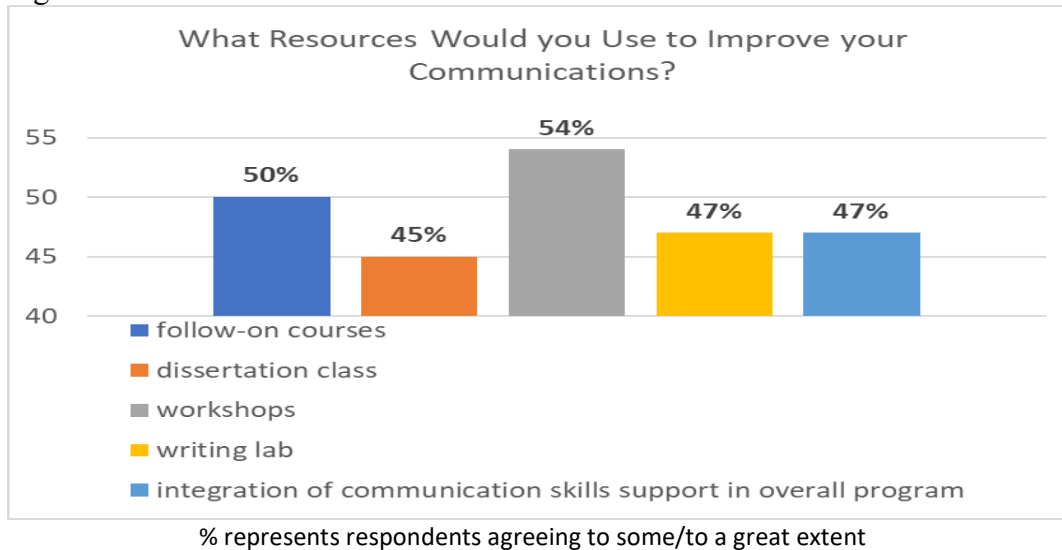
### Developing Resources to Support the Ph.D. Engineering Student

Although survey feedback on the writing and oral communications courses is positive, i.e. students feel they are getting value in terms of mastering academic forms for communication and the tools to pursue continued improvement, they universally profess a need for more comprehensive resources beyond the walls of a traditional classroom, and on a continuing basis. This is in part a reflection of the fact that writing and speaking skills improve gradually and represent life-long effort. Survey respondents were asked what other resources they would want to utilize to improve their communication skills. Workshops, a writing lab, dissertation support were noted as valuable resources.

## Specialized Communication Courses, Workshops, Individual Coaching

Student survey responses show below in Figure 6 interest in workshops, additional courses, a writing lab and more integration of communication skills support in their program. Among the strategies that can be employed so that students have greater opportunity to improve through continued practice, are regular workshops, face-to-face coaching, web-based tools, communication-based modules incorporated into core classes, and the development of social-based activities that provide outlets for graduate students to engage with native speakers and engineering students in other fields. As international graduate engineering students often (and understandably) seek out fellow students from their own native country as a bridge to functioning in an American university, they miss opportunity to build basic fluencies in writing and speaking. Several survey respondents note that they would attend open sessions to exchange cultural information and improve language skills with native speakers.

Figure 6



## Making Use of a Traditional Classroom Setting

Ph.D. engineering students in a communications course represent a somewhat specialized student population in terms of background and skill sets. In short, specialization and achievement in their field is matched with insufficient communication skills to disseminate sophisticated knowledge with the necessary precision. Both native and non-native speakers struggle with this complex task--made more challenging due to the nature of the material itself.

Inherently writing and oral communications courses have a social element that can be used as a base for driving expression of technical material. Students have focus for work that meets immediate goals like preparation for qualifying exams, proposals, dissertations and journal paper submissions. They are motivated and grateful for assistance with these important efforts yet can lack the commiserate level of engagement with broader activities related to mastering communication.

Through two decades of experimentation in the classroom, a few areas have shown promise in generating interactions in topic areas that can be related to student's specialized fields. First, assignments and accompanying discussion around ethical concerns in student's areas of research is a fruitful in promoting spontaneous discussion and concerted writing effort. Surprisingly, graduate engineering students do not generally have substantial experience reflecting on broader implications of their research and consequences. Sitting in the classroom with Ph.D. students from other fields and discussing writing or presenting their work provides a chance to develop a sense of audience beyond those who are part of their technical specialty.

Examining ethical issues provides common ground for students from multiple disciplines within engineering, and serves to generate thought and communication efforts that link students to wider audiences in addition to improving their confidence and general facilities to communicate with those in their specific area as well. A second thematic element that has generated focused social connection beyond technical material in oral communications courses involves sharing information about home cultures. Providing students the opportunity to share their path to a U.S. university allows foreign students to connect, and native students for their part enjoy explaining how things work in the American system.

Giving some space for graduate students to define their identity to others in the class has served to enliven discourse, and is particularly helpful in generating input from less effusive students. Allowing students to learn about each other in this way seems to support a collaborative and less asymmetrical classroom dynamic, and is in line with literature that argues against the traditional adjustment idea that foreign students bear the full burden of adaptation to US academic culture [19].

### **Meeting the Needs of International Engineering Students**

Engineering graduate students who are non-native speakers (NNS) face significant hurdles that reach beyond the course of their programs and continue through their career path whether in academia or industry. Given dramatic trends showing increasing numbers of international students entering programs in STEM fields, it is worthwhile to investigate the needs of this demographic profile to ensure that their education has properly prepared them to succeed. While in 1994, 40% of doctoral students enrolled in computer science were international, by 2015 this number increased to 64%, according to an annual survey conducted by the Computing Research Association (<https://cra.org/crn/wp-content/uploads/sites/7/2017/05/2016-Taulbee-Survey.pdf>).

The majority of Ph.D. students have already had a great deal of language instruction, including the basics of English vocabulary and grammar. The nuances of usage and academic conventions tend to be less familiar, but more easily applied than attaining facility with less formal speaking and writing demands. Offering individual courses for students to improve their writing and speaking skills are supportive of overall improvement, yet discrete classes risk partitioning off efforts to develop these skills that could potentially be applied and integrated throughout engineering graduate programs.

As described by [19], identifying the specific needs of international students should involve more than a uni-directional adjustment. In a departure from the dominant view that international

students must somehow overcome linguistic difficulties on their own, Ma notes that “learning about these students is the precondition for learning from them,” and all parties, including domestic students, faculty and administrators are stakeholders in this process [19, p.5]. Likewise, [20], studying Korean international students in several US universities concludes that more effort by U.S. institutions to develop strategies to help international students fulfill their educational goals and understand needs would serve both students and host institutions.

## Recommendations

This paper proposes an integrated approach that involves creating a learning environment for all Ph.D. engineering students to build communication facilities in a process that encompasses the duration of their graduate school program. Furthermore, to develop engineering leaders of the future, greater knowledge of diverse graduate students’ needs is required to better prepare them for the future. Many students who take the offered courses at our university identify feelings of isolation and perceive vulnerability in terms of their communications which affect their ability to participate fully in their scholarly community.

Preliminary research presented here reflects the voices of numerous international Ph.D. engineering students, and as such suggests that a variety of supports for engineering graduate students to improve their communication skills is needed. Barriers are identified, namely how to fit in this vital skill in the midst of a rigorous doctoral program. Given that improving one’s communications, particularly writing skill is honed over time, in addition to the special challenges that writing in the field of engineering presents, a holistic approach to provide integrated and comprehensive supports throughout student’s Ph.D. programs warrants further investigation as a model.

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