AC 2012-4268: UNDERSTANDING FACULTY AND STUDENT BELIEFS ABOUT TEAMWORK AND COMMUNICATION SKILLS

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Understanding Faculty and Student Beliefs about Teamwork & Communication Skills

Abstract

Strong communication and teamwork skills remain essential for engineering graduates in both academic and industry settings. They are considered by ABET to be key student learning outcomes for accreditation and are consistently high on employers list of necessary skills for new hires. Despite recognition of their importance, gaps in teaching these skills persist. While extensive research on communication pedagogy exists, teamwork suffers from a dearth of research on effective pedagogies. Regardless of existing research suggesting the significance, relatively few engineering courses integrate communication and teamwork skills. Our three-year mixed methods study grounded in motivation theory seeks to explore faculty and student beliefs about teamwork and communication, and to close the critical gaps between knowledge, belief, and practice. This paper focuses on outcomes from Phase1, which included 50 interviews with faculty from civil, mechanical and industrial/system engineering. We address the research question: How do faculty believe they are teaching teamwork and communication skills? Our findings suggest faculty approach teaching teamwork and communication differently. They typically have more structured definitions of good communication skills and, similarly, more structured strategies for teaching communication skills. In comparison, the interviews revealed less structured ways of talking about good teamwork skills and more ad hoc ways of teaching such skills.

Introduction: Teamwork and communication in the engineering classroom

Communication and teamwork skills remain a top-priority outcome for engineering graduates in both academic and industry settings. They are considered by ABET to be key student learning outcomes for accreditation [1] and are consistently high on employers list of necessary skills for new hires [2, 3]. Despite recognition of the importance of these skills in the workplace, there is minimal integration into engineering courses. In their 2008 survey of engineering faculty, for example, House et al. [4] found that faculty who do incorporate communication into their courses reported minimal support for their efforts from their colleagues (what about department or university). Both a 2007 survey by House et al. of technical communication skills or practices of faculty [5] and a 2006 survey by Paretti et al. [6] found little widespread collaboration between engineering faculty and those with expertise in communication pedagogy (e.g. technical communication and writing across the curriculum programs). While notable examples of such collaborations exist at institutions such as Northwestern University [7], Louisiana State [8], Virginia Tech [9], and elsewhere, these cases tend to be the exception rather than the rule. Less evidence is available regarding the integration of teamwork skills; surveys of capstone design faculty by both Pembridge et al. [10] and Howe et al. [11] show pervasive use of teams in capstone course. However, faculty of capstone courses do not report teamwork among the top 5 topics taught in the course. Furthermore, little if any research reports on the extent to which teamwork is integrated into other engineering courses.

Though the integration of communication and teamwork appears equally limited within engineering, when we turn to pedagogical approaches where sharp differences arise. The past

several decades have seen extensive work on communication pedagogy across the fields of composition, writing studies, and technical/professional communication. This research has led to books and anthologies on pedagogical (approaches)research e.g., [12, 13], special journal issues e.g., [14, 15], studies of student development e.g., [16], and numerous articles on teaching and learning both within engineering specifically and within the type of professions broadly. Few studies have focused on the teaching and learning of teamwork, though organizational behavior and systems engineering fields have provided extensive research on the practice (function) of teamwork within a classroom setting(Belbin's work on team roles [17] and Tuckman's work on team stages [18] are among the most notable). More recently, engineering education researchers have been focusing on the selection or group formation process and assessment of teams [19-22] However, much work remains to advance our understanding of how students learn to effectively function on teams and best practices on how faculty can facilitate the team learning.

The Importance of engineering faculty beliefs and practices

In their review article considering the "ABET professional skills," including teamwork and communication, Shuman et al. [23] ask the question, "Can they be taught?" and their answer is "a qualified yes" (p. 51). Noting, for example that the teaching delivery strategy required is not the traditional lecture format, but rather one that leverages strategies such as active learning and cooperative learning. The extensive body of research on communication pedagogy, moreover, reflects the powerful role that situated learning plays in the development of workplace skills [24-27]. That is, students learn to communicate effectively by practicing it in contexts that replicate their professional experiences (work conditions) and through meaningful feedback for that context. Given that teamwork is also a common professional skill, rather than simply a set of facts, it is reasonable to expect situated learning to play a prominent role in learning teamwork as well. As a result, effective teaching and learning of both skills inherently requires their intentional integration into engineering classes, with research-based pedagogies that support student learning.

Yet, as noted above, such integration is complicated and therefore conspicuously lacking. To better understand why the gap exists, this project will directly turn to the engineering faculty to articulate their beliefs and practices with respect to these two critical professional skills, teamwork and communication. Few studies have examined faculty beliefs about these important skills and how they enact their beliefs in their teaching practices, particularly in content heavy fundamental courses. Studies by Leydens [28] and House et al. [4] provide some insights regarding how faculty perceptions of communication, but much research is needed before these skills can be effectively and holistically integrated into engineering technical content and skill development.

To bridge this gap, we have begun a three-year mixed methods study design to explore the beliefs and practices of engineering faculty around teamwork and communication skills. The overall study was guided by motivation theory to understand teaching philosophies because previous research has suggested a link between faculty's beliefs and teaching practices [29, 30]. Before we are able to explore the underlying motivations for the teaching of teamwork and communication skills, we must first identify the practices currently used by engineering faculty. The identification of practices for teaching teamwork and communication skills is the foundation of this paper.

We focus on both teamwork and communication because the two are concomitant, linked closely in both the workplace and in academic settings. For example, students are frequently assigned to work in teams where the negotiation of workloads, tasks and exchange of information requires extensive interpersonal communication. Moreover, team projects often include written deliverables and verbal presentation components to faculty mentors or industry sponsors. Effective verbal and written reports require not just a combining of individual components, but the construction of a cohesive presentation by the entire team. Teamwork and communication are thus inseparable in many engineering contexts.

In this paper, we report findings about teaching practices from the qualitative phase of the study, which consisted of 50 in-depth interviews with faculty from civil, mechanical and industrial/system engineering. We address the research question: How do faculty believe they are teaching teamwork and communication skills? Understanding what faculty believe (their prior knowledge, conceptions, and potential misconceptions) is a critical first step to providing tools and opportunities to better support communication and teamwork pedagogy within engineering.

Methods

The overall project consists of three phases over three years. This paper focuses on the first phase, which explores faculty beliefs about the teaching and learning of communication and teamwork skills within undergraduate engineering curriculum. To accomplish that goal, we interviewed 50 faculty across five research sites. Partner universities (identified by pseudonyms) are described in Table 1.

Table 1: Partner Universities

School	Description	Fields
Southwest Tech (SW)	Small public technical institution southwest US, high transfer-in rate	CE, ME
Northwest (NW)	Large public institution, western US, degrees in arts and sciences and the professions, research focus	CE, ISE, ME
Midwest Tech (MW)	Small private technical institution, central US	CE, ME
South Central (SC)	Large public institution, central US, degrees in arts and sciences and the professions, research focus	CE, ISE, ME
Mid-Mountain (MM)	Medium public institution, western US, technical school, research focus	CE, ME

To narrow our sampling across the fields of engineering, we focused on civil engineering (CE), mechanical engineering (ME) and industrial and systems engineering (ISE). We chose ME and CE as typically large and traditional fields. ISE was included specifically because of the emphasis on team processes in many ISE programs and subfields. Interview participants were

solicited via email, with the help of site coordinators at each school; the participants are thus self-selected. We attempted to gather data from a diverse rank of participants, including adjunct, associate and full professors. Faculty interviews were semi-structured, artifact-based and were typically 40-50 minutes in duration. Two members of the research team conducted most of the interviews, with one researcher acting as primary interviewer and the second researcher focused on note-taking and environmental observations. We used open-ended questions to probe faculty beliefs regarding the teaching of teamwork and communication skills, with the purpose of better understanding how and where they believe these skills should be included in an undergraduate engineering curriculum. Prompts included:

- How would you describe your teaching style?
- When designing a course, how do you decide what to include/exclude?
- What does good communication/teamwork look like?
- Where are students learning basic communication/teamwork skills?
- What are some ways that communication/teamwork skills are used in your courses?
- What is the most important thing you can teach your students? How do you teach it?

We also asked participants to bring samples of assignments or syllabi that represent the ways that they teach communication and teamwork skills. These artifacts provided a tangible way to probe more specifically about the ways that faculty integrate the practice of these skills into the structure of their courses. They also helped us to understand the ways in which these skills are assessed and the mechanisms by which faculty provide feedback on assignments.

After each interview, the researchers compiled a set of field notes, highlighting key elements of the conversation and of the interview conditions (environment). The interviews were transcribed verbatim and analyzed using MAXQDA software. Based on our field notes, we developed broad, a priori coding categories to apply to the interviews to identify ways that teamwork and communication skills are taught [31]. These categories included Structured Activities, Ad Hoc Activities, and Reliance on Others. We also include the category "Don't Teach" for faculty that stated they do not believe they teach such skills. After applying the broad codes to all interviews, we developed more detailed and specific sub-codes for each broad category using open-coding strategies [31]. The sub-codes emerged separately from the data for communication and teamwork.

Interviews were coded separately for teamwork and communication by two graduate research assistants. However, to enhance the trustworthiness of the data analysis, the research team applied a data triangulation strategy [32]. A detailed codebook was developed and used to independently code the first ten interviews. Researchers met several times to discuss their coding selections until consensus was reached. The remaining interviews were divided and coded by a primary coder, and then reviewed by a secondary coder. The entire research team (all paper authors) met periodically to discuss emerging themes, code definitions, and patterns observed within the coded data. The final categories and sub-categories in the codebook are detailed in the results section where the codes and examples are given.

To develop an understanding of the general trends for this analysis, we quantitized the data by counting (summing) the number of people who mentioned each strategy and then the total number of times each strategy was mentioned across all interviews. Quantitizing the data is

integral to mixed methods research and refers to the numerical translation of qualitative data into quantitative data [33]. In this phase of our study, quantitizing the data is necessary to characterize and describe the frequencies of categories and to inform the development of a survey for broader data collection.

Results and discussion

Strategies for teaching communication and teamwork: Structured, ad hoc, and other people

The focus of this analysis was to identify the ways in which faculty indicate that they teach teamwork and communication skills. Table 2 shows the broad codes (column 1a, vertical labels) and subcodes (column 1b, horizontal rows). The table also shows the number of participants who cited each strategy as well as the overall number of times the strategy. Comparing these two numbers provides an indication of singular mention vs. extensive discussion. Data are separated into columns for teamwork and communication. The emergent patterns, described in greater detail following the table, include: 1) faculty describe more structured strategies for teaching communication skills and more ad hoc strategies for teaching teamwork skills, 2) faculty have a higher tendency to indicate that "someone else" teaches communication skills, and 3) consistent with not having structured strategies to teach teamwork faculty report that they do not teach teamwork, and 4) it's a skill that students can only learn by "doing it," though 20% of the faculty interviewed did not know where students had the opportunity to learn teamwork and communication skills.

Table 2: Strategies Faculty Use to Teach Teamwork and Communication

Teaching Strategies/Activities		Communication n= 50		Teamwork n=50	
		# of participants who mention strategy	Total # of times strategy is mentioned	# of participants who mention strategy	Total # of times strategy is mentioned
Structured Activities	Lecture/classroom activity	5	10	11	37
	Use rubrics	15	28	3	8
	peer evaluation	11	16	37	57
	Provide templates/examples	33	56	NA	NA
	Students give presentations	25	73	NA	NA
	Skills are graded	25	48	18	57
	Provide writing assignments	46	113	NA	NA
	"we talk about" it	12	20	12	17
	Formal Instructor feedback	38	126	31	43
Ad Hoc Activities	"Learning by doing"	6	9	41	64
	impromptu guidance	13	19	13	17
	Conflict intervention	NA	NA	20	35
	"they work on teams"	NA	NA	21	26
Reliance on Others	Someone else teaches - general	6	11	2	2
	Elsewhere in engineering	17	36	10	15
	Elsewhere outside engineering	16	17	1	1
	Don't know how/where its taught	0	0	12	14

Structured strategies for communication skills and ad hoc strategies for teamwork skills

Faculty interviewed in the study report having more structured strategies for teaching communication; however, more ad hoc strategies were reported for teaching teamwork. Overall, there were 490 coded segments that referenced structured instruction for communication, but only 219 references to "structured instruction" for teamwork. Conversely, there were more sub-codes for ad hoc ways of teaching teamwork (4) than for communication (2) and mentions of ad hoc ways of teaching teamwork outweighed mentions of ad hoc ways of teaching communication.

Communication strategies include writing various types of reports, (i.e. memos, research reports, executive summaries) formal presentations, (i.e. pitches to clients, presentations to various audiences, progress reports) and the use of templates, examples, and written feedback to guide students learning communication skills required for a practicing engineer.. Teamwork skills tend to be fostered most often through simply having students "work on teams" or "learn by doing". Also, impromptu interactions and as-needed interventions to resolve conflicts were also reported often. The two quotations, below, illustrate the types of comments that distinguish structured from ad hoc activities:

Structured strategies for communication:

> We talk a lot about referencing, and how to do that properly and what's expected. Uh, we talk about literature surveying, and how to do that, and what's expected, in terms of that. It's, yeah, it's fairly structured. (ISE, NW University)

Ad hoc strategies for teamwork:

> I mean, you don't, we don't try to say, well this is, this, this is what constitutes a good team, you know, we don't try to give them a prescription of what a good team consists of. (ME, SW Tech)

As the quotations illustrate, structured activities are intentional interventions provided to the entire class and include opportunities to for students to practice, for students to receive direct feedback, and/or for formal direct instruction or lectures. Conversely, *Ad hoc* activities reflect less intentionality and were often not directed at the class as a whole (instead targeting an individual students' or specific teams with difficulties). Lastly, the informal class activity tended to shy away from prescriptive instruction.

Someone else teaches communication

In addition to recognizing and articulating more structured ways of teaching communication, the faculty interviewed also often indicated that "someone else" teaches communication skills. Our data show that more than half of the participants, 31 out of 50, said that someone else teaches communication therefore it is not within their responsibility. Here are some exemplar quotes:

> We're not teaching them, you know, how to write a thesis or something like that , although, they do that, you know, in their capstone design course, but that's not, we, we're assuming that they're getting that more in their English and technical writing courses. (CE, SW Tech)

> We pigeon holed it [communication] in different parts of the curriculum. So, it becomes part of the capstone and part of the technical communication courses. (ME, NW University)

As noted in Table 1 and suggested by the two quotations above, most participants identified one of two locations: outside engineering (most often in technical communication courses), or within engineering (most often in first-year or capstone design courses).

I don't teach te**a**mwork

In addition to not having structured strategies for teaching or assessing teamwork, faculty report that teamwork is not a topic that is explicitly taught anywhere in the curriculum. Numerically this is evident by 41 out of 50 participants saying that students learn teamwork by "doing it": and not through any formal teaching strategies, while only 13 out of 50 saying that someone else teaches it. Participants believe students are learning the teamwork skills but not that teamwork is being explicitly taught. Consider the following two quotes:

> Uh, I do not give them any instruction in teamwork. Or in leadership. I, uh, I think that's probably fairly common, we let them know what the expectations are for the final product, and it's their job to figure out how to do it. (CE, SC University)
>
> We never really bring it up. We don't, we don't bring up teamwork as a topic in the curriculum. We tell them they are in teams. (ME, MM Tech)

Both of these participants speak broadly about not teaching teamwork in the engineering program as a common approach suggesting that the students just figure out how to do it simply by being put in teams. This assumes students have multiple opportunities to work on teams throughout the engineering curriculum such as freshman design and capstone design.

Reasons for not teaching communication and teamwork

In addition to faculty who articulated structured and ad hoc strategies for teaching these two skills, the participants in this study also included faculty who do not teach those skills at all. In some cases, participants did not provide rationales for not teaching teamwork and communications skill. However in many cases in terms of teamwork, faculty articulated three key rationales: lack of value, lack of knowledge, and lack of time, as summarized in Table 3.

Table 3: Reasons Faculty Do Not Teach Teamwork and Communication

Teaching Strategies/Activities		**Communication n= 50**		**Teamwork n=50**	
		# of participants who mention reason	**Total # of times reason is mentioned**	**# of participants who mention reason**	**Total # of times reason is mentioned**
Don't teach	Don't teach it	10	17	9	11
	Skills not a concern	3	5	8	10
	Don't know how to teach it	4	4	11	12
	No time to teach	6	6	8	11

Importantly, the interview protocol focused on faculty beliefs about teaching and learning and did not explicitly seek to probe rationales for not teaching these skills. In addition, as noted in the Methods section, faculty participants were voluntary and most participants agreed to the interview because they had an interest in these skills; as a result, the quantification provided here may not be representative of the general population either in terms of the percent of faculty who do not teach these skills or the distribution of rationales among those faculty. Still, the reasons themselves, as well as the balance of comments between communication and teamwork, is intriguing. While the number of faculty who don't teach these skills is relatively constant, many more faculty do not value teamwork and do not know how to teach it in comparison to communication.

Conclusion

In exploring faculty beliefs and practices regarding communication and teamwork, the interview findings presented in this paper highlight that although the two skills are frequently intertwined in engineering practice, the teaching and learning strategies and faculty knowledge base

surrounding the two skills differ markedly. Both skills, teamwork and communication, are situated skills learned in context particularly in the design experience. Whereas the interview participants seem to subscribe to a diverse set of structured approaches or tools for teaching communication and with fewer systematic strategies for teaching teamwork. Moreover, those who don't teach teamwork are almost three times as likely to site "lack of knowledge" as a reason for not teaching the skill, which may have faculty development implications. At the same time, with respect to the communication skills, faculty show a much stronger belief in the idea that it is taught "elsewhere" in the curriculum, either in other engineering (design) courses or in designated technical writing courses. Many interviewees could (and did) identify specific courses by number or name individual faculty inside or outside the department who were "responsible" for communication and teamwork skill development of students.

Teaching communication

The notable reliance on "other" courses for the development of communication skills reflects, in large part, the existence of technical communication as a discipline This includes a long history of technical writing courses for engineering students and the presence at many universities of Writing Across the Curriculum (WAC) programs that often include writing-intensive (WI) designations for specific courses. The WI courses were mentioned in a number of different interviews as faculty identified sites of learning. Interestingly, however, even as faculty pointed to these external sources as places of instruction where students "learn" communication in a formal sense, they also identified communication-based assignments in their own courses (e.g. reports and presentations). That is, while a small number of faculty participants did not include assignments that they considered communication-related several claiming to not to teach communication explicitly still required communication artifacts or deliverables. The prominence of communication among the faculty interviewed is reinforced by the low number of interview participants who did not consider communication a matter of concern; only 3 of the 50 interviewees did not consider it part of the curriculum.

These results suggest important opportunities for dialogue and collaboration among engineering faculty within a department and between engineering faculty and technical communication or WAC faculty to help identify expectations, perceptions of quality and criteria for effective communication, areas of overlap, skills that are not being addressed, and opportunities for reinforcement or development as students move through the curriculum. A richer understanding of faculty motivation with respect to these issues, to be developed in the next phase of this study, holds strong promise for identifying strategies and tools to support this dialogue. For example, research shows that faculty are uncomfortable teaching skills for which they also have low self-efficacy [34]. Building faculty self-efficacy may be a critical part of such dialogs.

Teaching teamwork

The findings surrounding teamwork, in contrast, show a strong need for more explicit discussions about the teaching and learning of teamwork skills – not only what those skills are, but how faculty can effectively support their development across the curriculum. The dominant belief in "learn by doing" and the frequency with which faculty believe students learning teamwork simply by working in groups suggests a significant barrier that may need to be addressed. Changing such underlying beliefs can be challenging, but here, too, motivation theory

can provide guidance for developing approaches that help faculty identify both the value of teamwork and effective strategies for teaching critical skills. Valuing activities is a critical precursor to engaging in them [34]. Moreover, the same kinds of dialogues that can support the integration of communication skills across the curriculum may also prove fruitful for teamwork; many technical communication faculty already address teaming issues in collaborative writing projects, for example, while faculty in organizational behavior and related fields may have critical expertise in workplace teaming.

By acquiring a better understanding of faculty beliefs and practices, the work presented here and the subsequent project phases seek to provide engineering faculty with tools and strategies to better support students' professional development. Teamwork and communication are inextricable from engineering practice in the contemporary workplace; they should be equally embedded in the contemporary classroom.

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