AC 2011-2241: REVISITING COMMUNICATION EXPERIENCES TO PREPARE FOR PROFESSIONAL PRACTICE

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Revisiting Communication Experiences to Prepare for Professional Practice

Abstract

The ability to communicate effectively is a critical competency for engineers. According to the future envisioned in the Engineer of 2020,[1] in ABET criteria for accreditation,[2,3] and scholarship in the fields of engineering education and technical and professional communication,[4] the role of communication in the work life of engineers is becoming more complex and far reaching. We need to help our students prepare for the challenges associated with this expanded role.

The exploratory study reported here investigates students' conceptions of the communication of engineers by analyzing the content of portfolios created by five undergraduates in a studio setting. Responses to selected survey items were also analyzed. We found that each of the students discussed or otherwise acknowledged (1) the situated nature of communication, (2) the ways in which communication can be empowering, and (3) the importance of familiarity with a broad range of communication activities for their future professional lives. The ways in which students attended to these dimensions of communication varied greatly between students.

Introduction

> *Strong communication skills can really make an engineer stand out among their peers, especially since engineers are known for their expertise and creativity, but lack of communication skills. Engineers that can communicate well are better collaborators, and often get more opportunities to shine, since they are usually the team member that presents work.*

The above quote, taken from a student portfolio, shows a recognition of the empowering nature of effective communication.

In this paper we report on an exploratory study aimed at discovering the ways in which engineering undergraduates' think about the communication activities they will be involved in as practicing engineers. The purpose of the study was to guide our thinking as we expanded our current research on engineering preparedness portfolios to include a studio series devoted to communication.

In our ongoing research on preparedness portfolios,[5-9] we have students create portfolios in a collaborative studio setting. In a studio series held in spring of 2010, we asked students to create portfolios that focused on a single competency. Interestingly, five of the eleven students in that studio series selected communication as their focus. The portfolios and survey responses of these five students became the basis of this exploratory study.

We selected three dimensions of communication by which to organize and focus our inquiry into students' conceptions: situatedness, empowerment, and breadth. These dimensions represent important ways of thinking about communication, and their selection was motivated by needs

expressed by professional organizations and practitioners, by scholarship on writing and other forms of communication, and by our own experiences teaching professional communication to engineering undergraduates and directing an engineering communication program.

Thus, in this paper, we seek to answer the following question:

> For these five students who created communication portfolios and responded to survey questions about their experience creating the portfolios, to what extent and in what ways do their portfolios and survey responses include or reflect situatedness, empowerment, and breadth with respect to communication?

In the remainder of this paper, we provide background and rationale for our study, describe the methods we used, present our results, and discuss their implications.

Background and Rationale

Effective communication is well recognized as a crucial ingredient for success as a practicing engineer. In the future painted by the NAE with respect to what engineering and engineering education will look like in 2020, the need for excellent and varied communication skills figures prominently: "We envision a world where communication is enabled by an ability to listen effectively as well as to communicate through oral, visual, and written mechanisms" (p. 55).[1] In addition, ABET lists the "ability to communicate effectively" and the "recognition of the need for, and an ability to engage in life-long learning" as two of the eleven outcomes in their 2010-11 Criteria for Accrediting Engineering Programs (p. 3).[2] Programs seeking and maintaining accreditation must be able to demonstrate that their students attain these outcomes before graduation.

NAE addresses the importance of situating communication within a given audience and context. Specifically, the *Engineer of 2020* calls for students to be prepared to communicate effectively on environmental and political issues of global scale: "The engineering profession recognizes that engineers need to work in teams, communicate with multiple audiences, and immerse themselves in public policy debates and will need to do so more effectively in the future" (p. 43).[1] And NAE asks whether or not engineers will have a chance to shape that future—to be in positions of power—and how we, as educators, can best prepare our students for leadership roles. The future described by NAE places engineers in positions within organizational structures where they have the capacity to effect change: "The increasing imperative for accountability will necessitate an ability to communicate convincingly and to shape the opinions and attitudes of other engineers and the public" (p. 55).[1] NAE also calls for competency with different forms of communication, finding that the global environment of the 2020 engineer, with rapidly changing technologies, will require "effective use of virtual communication tools" (p. 55).[1]

In addition, educators are looking at the major challenges facing professional communication instruction for engineering students today; they are wrestling with the effects of changes in technology on the notion and practice of effective communication.[4] The pervasiveness of PowerPoint and Excel in the workplace calls for more sophisticated oral presentation and graphic skills. The ubiquity of email, IMS, and video-chat creates a demand for greater ability to manage

multiple communication tools simultaneously while maintaining workflow. In addition, technologies have expanded the working environment and knowledge base for workers, making it crucial for them to take charge of their own learning in order to keep current with increasingly complex technical skills. In short, engineers must be able to reflect on and appreciate their prior experiences and competencies in order to leverage them in new situations, and they must be proactive in their pursuit of new knowledge to support that mobility.

There are many interesting challenges that lay ahead for educators involved in preparing students for professional practice today. Paretti and McNair[4] describe opportunities for further research in their introduction to a special issue of IEEE Professional Transactions on Communication; two of the most relevant here include:

- *what "effective communication" is in engineering contexts, how engineers understand themselves as communicators, and how they constitute and enact rhetorical practice*

- *how engineering students learn to communicate in a range of media and genres as they move from freshmen to seniors and out into the workplace*

It was against this backdrop of professional visioning and educational focus, as well as our own professional experiences mentioned above, that we developed the dimensions that we use in this study to examine students' notions of the communication of practicing engineers: situatedness, empowerment, and breadth.

Writing is a socially situated activity—the context in which it is embedded defines it: "all writing is a response to, and assumes as a starting point, a situation.[9] Genres were first described as social action by Carolyn Miller[10]; Carol Berkenkotter and Thomas Huckin describe genres as dynamic, rhetorical structures.[11] These works, and those of other genre theorists and rhetoricians, resulted in the definition of genre as a typified response to recurrent social or cultural situations.[12, 13, 14] Charles Bazerman[15] notes that good writers who have experience writing in multiple communities understand the need to adjust their writing, their perspective, and even their social motives, to suit their audiences. Dannels[16] draws parallels to the field of communication, asserting that speaking is a contextually-motivated, cultural event. With professional communication instruction becoming increasingly focused on cases and client-based projects, and with technology driving changes in workplace writing, writing curriculum is moving away from formulaic responses to rhetorical situations in favor of providing students with some theoretical background in writing and rhetoric.[17] Understanding students' prior genre knowledge is believed to be helpful for designing educational experiences that assist students as they acquire genre knowledge that will in turn give them strategies they can transfer to new contexts, which will help them in their engineering careers.[12, 18, 19]

Our use of empowerment is based on Dorothy Winsor's [20] use of the term agency: the capacity to bring about desired actions that reinforce or go against existing structures. Winsor's dual focus on opportunity for freedom of action (i.e., capacity) and desire to bring about action (i.e., intent) aligns with the work of several scholars.[21-24] In her study of engineers in the workplace, Winsor[20] discusses rhetorical agency not as a characteristic of an individual but rather as the intersection of an individual's desires and the opportunity to act on those desires. However, Winsor also

suggests that opportunity and intent are not sufficient for agency; the would-be agent must also skillfully employ rhetoric to make the texts they author effective at giving them agency. In her 2007 study of the use of regulatory documents, Winsor[25] found that the engineers she studied used rhetorical and social resources to effect changes and, further, that the strength of their power to effect change was relative to the extent of their participation in the writing.

Methods

In this section, we operationalize our dimensions, describe the studio intervention, introduce the participants, and present our data collection and analysis approach.

Operationalization of dimensions

In our study, we use the term situatedness to refer to the context in which a given communication is embedded and to the ways in which the communication is adapted for that context. Operationalized for this study, situatedness means that students' portfolio content and survey responses reveal an attention to audience, purpose, and use in communication and to the importance of tailoring communication for a given situation.

We use the term empowerment to refer to the ways in which effective communication can be used to exert power or influence. Operationalized for this study, empowerment means that students' portfolio content and survey responses reveal a recognition that effective communication can make things happen for self or others.

We use the term breadth to refer to students' thinking about what counts as communication for practicing engineers. Operationalized for this study, breadth means that (1) students' portfolio content and survey responses reveal a recognition of a range of communication types: modality of the message (e.g., auditory versus visual), choice of medium (e.g., email threads, You Tube videos, conference presentations), the textual or graphical nature of the communication; and (2) students' portfolios includes artifacts of varying types (i.e., that students provide more than typical written documents) and that are drawn from lifewide experiences beyond school (e.g., extracurricular activities, employment).

The studio intervention

As mentioned earlier, the participants in this study were part of portfolio studies series conducted in spring of 2010. Participants attended five, two-hour studio sessions and created portfolios in which they made arguments about their preparedness for the engineering workplace with respect to a single competency of their choice (e.g., analytical skills, leadership). Participants were given a few basic guidelines and a great deal of freedom. In terms of guidelines, they were asked to include the following components in their portfolios: (1) a professional statement that makes an argument about preparedness, (2) artifacts that provide evidence for claims made in the professional statement, and (3) annotations that describe how each artifact supports one or more of the claims made. Participants were also asked to implement their portfolios in a simple website—a university tool was provided, but they could use others. Aside from these basic requirements, participants had total control over the content of their portfolios. Participants

revisited their past experiences to find evidence for their preparedness claims, responded to surveys, provided in-session feedback, and participated in interviews. The workshop setting provided a collaborative, supportive, and student-driven environment in which peer review, camaraderie, and accountability to peers were significant components. Together participants tried out language, reviewed each others' work, discussed, revised, and—in the end—presented compelling arguments about their preparedness to communicate as practicing engineers. This portfolio series was a research project and was not associated with a course. As such, the participants were paid, and the facilitator made no judgments or assessments of the participants' work. We refer readers wanting more details about this intervention to several articles describing previous work that we have done using this methodology.[5-8]

Participants

The five participants whose portfolio content and survey responses we analyzed in this study chose to make preparedness portfolios that focused entirely on communication. This was the largest number of participants choosing any one particular competency, a statistic that supports the idea that students know communication to be an important competency for their futures as practicing engineers. All five of these participants were women. Given their self-selection for making communication portfolios, it is interesting to note that not all of the participants rated their communication skills highly (see Appendix A). On the other hand, as might be expected, they all rated the importance of communication skills for engineering practice very highly Also, our participants varied in how they rated their familiarity with the activities of practicing engineers. We turn now to the approach we used for our data collection and analysis.

Data collection and analysis approach

For this study, we analyzed content from five portfolios and five sets of responses to three post-survey questions, as detailed below:

<u>Portfolio content</u>

- Professional statements that ranged in length from approximately 230 to 580 words
- Artifact annotations that ranged in length from approximately 150 to 330 words (number of annotations varied from three to five)
- Artifacts (this data source pertains only to the breadth dimension of the analysis)
    - Artifact type: we noted whether or not the participant provided artifacts other than written documents (e.g., PowerPoint presentations, code, team photographs)
    - Artifact source: we noted whether or not the participant provided artifacts drawn from experience beyond school (e.g., volunteer work, organization membership)

<u>Survey responses</u>

- Responses to three open-ended items on the post-survey
    - "What are your chief take-aways from this experience?"
    - "Regarding the workshops themselves, what were your chief take-aways from the sessions as a whole, from the group discussions, and from questions that were asked?"
    - "Please describe the aspects of your competency-based portfolio you like the most."

These data sources were coded for our three dimensions of interest (situatedness, empowerment, and breadth). Specifically, the first author of this paper and another graduate student double coded the professional statements, artifact annotations, and survey responses for references to situatedness and empowerment, using a coding scheme we developed. Independent agreement between coders was 70% on the initial pass. After a brief discussion in which any misunderstandings of the coding scheme or core concepts were clarified, the coders reached 94% agreement. The first author coded the professional statements, artifact annotations, and survey responses for references to breadth and also catalogued the artifact type and source. The data were explored for emergent themes across the participants.[26]

Results

In this section we provide answers to our original question: To what extent and in what ways do these five students' portfolios and survey responses include or reflect situatedness, empowerment, and breadth with respect to communication?

The extent to which portfolio content and survey responses include or reflect situatedness, empowerment, and breadth

Our analysis revealed that our three dimensions of interest (i.e., situatedness, empowerment, and breadth) were prevalent, appearing for all of the participants in nearly all of the data sources (i.e., the professional statements, annotations, and survey responses) as shown in Table 1 (above the dotted line). Empowerment and breadth were just slightly more prevalent than situatedness.

Table 1. Extent of appearances of situatedness, empowerment, and breadth in participants' portfolios and survey responses, and categorization of artifacts by type and source.

	Babette	Lindsey	Courtney	Jessica	Ming
Situatedness					
Prof Statement	Yes	Yes	Yes	Yes	Yes
Annotations	Yes	Yes	Yes	Yes	No
Survey Responses	No	Yes	No	Yes	Yes
Empowerment					
Prof Statement	Yes	Yes	Yes	Yes	Yes
Annotations	Yes	Yes	Yes	Yes	Yes
Survey Responses	No	Yes	No	Yes	Yes
Breadth					
Prof Statement	Yes	Yes	Yes	Yes	Yes
Annotations	Yes	Yes	Yes	Yes	Yes
Survey Responses	Yes	No	Yes	No	Yes
Artifacts—beyond written	Yes	Yes	Yes	Yes	Yes
Artifacts—beyond school	No	No	No	Yes	Yes

It is important to make a few comments about the units of analysis (i.e., the professional statement, set of annotations, and set of three survey questions for each participant). For example, a "yes" in the table for a participant in the annotation row under empowerment could

mean that empowerment appeared in just one of that participants' annotations, or two, or all of them. This same idea would hold for the survey responses.

In addition, as part of our analysis of breadth, we examined the types of artifacts presented and their sources. We recorded whether or not any of the artifacts presented by a participant went beyond written documents (e.g., oral presentations, photographs, video clips) and whether or not any of the artifacts were drawn from experiences beyond school (e.g., memberships in organizations, volunteer activities). Our examination reveals that all five of the participants included more than just written documents in their portfolios, but that just two of the participants gathered artifacts from experiences outside of school (see the bottom two rows of Table 1). Again, it is important to consider the unit of analysis in interpreting these findings. For example, a "yes" in the table for artifacts beyond school indicates that a participant included at least one artifact that was not just a written document, but it does not indicate how many of those types of artifacts were presented by that participant.

In summary, our analysis above gives a preliminary (and rather coarse-grained) look at the extent to which participants addressed our dimensions. We found (1) that all of our participants addressed issues of situatedness; (2) that all participants appeared to engage with empowerment; (3) that all talked about the importance of different forms of communication and presented artifacts other than written documents; and, finally (4) that a few participants looked beyond school to find artifacts that showed evidence of their preparedness. We turn now to the main portion of the analysis to examine the ways in which the dimensions were addressed.

Ways in which portfolio content and survey responses include or reflect situatedness, empowerment, and breadth

In the previous section, we saw that prevalence of situatedness, empowerment, and breadth was somewhat uniform across participants and data sources. In contrast, the ways in which participants addressed the different dimensions varied greatly. This section describes the thematic analysis for each of the dimensions.

Situatedness

Two themes emerged from our data regarding situatedness: (1) level of complexity, and (2) specificity of adaptation. Level of complexity refers to the participants' description of the situation in which a communication is embedded. Specificity of adaptation refers to whether or not (and in how much detail) participants described how they adapted their communication to a given situation.

Level of complexity. Our working definition of situatedness includes the entire communication context—for example, the intended audience(s), the purpose, and the conditions of use. The level of complexity of the participants' involvement with situatedness ranged from those who acknowledged a basic concern for audience (all participants) to those who attended to the full communication context. Some excerpts from participants' portfolios and survey responses provide illustration.

In this first example, the participant talks about communicating effectively with her audience, but she makes no reference to the intended purpose and use the audience may have for her communication. Therefore, this example represents a rather simple conception of the situated nature of communication.

> *Through my engineering course projects, extracurricular activities and competitions, I have developed good communication skills to help me communicate effectively with others.*

In the next example, the participant discusses analyzing and targeting her audience, and she also goes on to acknowledge the need to address the situation in which it is embedded. She stops short of describing the specific context, but she is clearly aware of its importance and mentions it generally. This passage represents a more sophisticated notion of situatedness than the previous example, but it is does not attend to all of the complexities the communication context.

> *I have demonstrated that I can accurately analyze my audience, determine the most important and relevant ideas, and then convey these ideas to that audience in the most appropriate manner for the situation.*

In this final example, the participant is talking not only about the importance of effective communication to a particular audience (i.e., end users), but also about the purpose and use (i.e., to know how to get the best use out of the technology. So, in this case, the participant reveals a fairly complex level of involvement with situatedness.

> *The purpose of a new technology or software program typically is to help our life become more convenient. Without effective communication to the possible users, the new technology or product is useless since the users will not know how to utilize the technology or product to its fullest potential.*

In summary, these examples seem to indicate that the participants in our study engaged with the notion of situatedness with varying levels of complexity. We turn now to the ways that participants discuss adapting their communication for particular situations.

Specificity of adaptation. Our working definition of situatedness includes participants' recognition of the importance of tailoring communication for a given situation Participants varied in the amount of detail they used in describing how they adapted their communication for a particular situation. Their statements ranged from no mention of adapting their communication for the context, to general statements about adapting, to specific ways in which they adapted—for example, writing style, document design, or presentation format. Again, excerpts from participants' portfolios and survey responses serve as examples.

In this first example, the participant explicitly calls out the importance of adapting her writing style for a given audience. She does not, however, talk about possible implementations of this idea. This participants' statement reveals a rather general notion of the need to adapt.

> *In order to communicate effectively with a given audience, it is important to identify the audience's needs and adapt one's writing style appropriately. These two artifacts illustrate my ability to convey technical information to two very different audiences: a lay audience and a highly specialized technical audience.*

In the next example, the participant describes the target audience specifically and discusses the fact that she adhered to certain conventions of the discourse community in which the communication is embedded. She also touches on the audiences' use of the communication. Thus, in this passage, the participant demonstrates not only a somewhat complex understanding of the entire communication context, but also begins to describe in very general terms the adaptations she made to meet this audience (i.e., preparing the document in SAMPE technical paper format).

> *The second artifact, 2010 SAMPE Student Symposium technical paper, was a paper I wrote for the annual SAMPE conference. SAMPE, the Society for the Advancement of Material and Process Engineering, is a technical society with a strong emphasis on composite materials… It also complies with the accepted SAMPE technical paper format, which makes it easy for a SAMPE reader to find the exact information he or she desires.*

In this next example, the participant is revealing a rather sophisticated notion of situatedness—one that includes a complex notion of the situation (i.e., reference to the audience and the time frame) and specific details about adaptation (i.e., tailoring the visual and oral elements for the situation).

> *I knew that my topic would not be expected to be interesting (especially when my speech was during the last week of class), so I made sure to include some visual appeal to my slides by adding colorful examples of the fish I was talking about, and to sound notably enthusiastic about my topic to keep my audience interested.*

One of the strongest examples of a very sophisticated notion of situatedness came from a participant who talks about a poster that she presented at an undergraduate symposium. In the following passage the participant articulates a thoughtful analysis of her audience and its purpose and use. She also describes explicitly how she adapted her communication to situate it in the context defined by that audience and purpose—a student research symposium.

> *Since I was not able to accompany my poster for the duration of the symposium, I had to ensure that the information I included was clear and that the reader was guided logically from one section to the next. I used a simple left-to-right top-to-bottom format, large descriptive headings, and a very uniform layout. A great deal of text was necessary to describe my research, but also included several figures to give the audience additional, visual information. I included my abstract to give the reader a good overview of my poster, and then elaborated on my research in the remaining space. The audience for this symposium included prospective students, current university students, professors, and the general public, so I had to include my technical content and also describe it in more detail than I would to a technical audience.*

To summarize, these examples reveal that our participants are thinking in a variety of ways about adapting their communication for the context in which it is embedded. As we will see in the next section, considerations of context often begin to overlap or merge with recognition of the empowering nature of communication.

Empowerment

Our working definition of empowerment deals with participants' recognition of the ability of effective communication to make things happen for self or others—that communication can enable one to exert power or influence. Three themes emerged in the data with respect to empowerment: (1) the ways of exerting power, (2) goals for exerting power, and (3) the extent of the power exerted.

Ways of exerting power. Participants' descriptions of the ways in which they exerted power through communication varied, as shown in the following excerpts from students' portfolios and survey responses.

In this first example, the participant is talking about specific means by which she can achieve an outcome through particular communication strategies (i.e., quick and easy tips) that are based on her knowledge of her audience (i.e., busy schedules).

> *I geared my pitch toward my audience (college students) by suggesting quick and easy tips (rather than difficult or time-intensive ones) since I knew that I would better persuade them to my stance if I provided advice that would not take a lot of time in their already busy schedules.*

In this next example, the participant describes some specific communication strategies (i.e., explaining programming and design decisions effectively) that will help move her forward to success.

> *I believe that this experience has taught me the importance of conveying my knowledge in a clear and concise way. In my opinion, this skill will be of great assistance when I enter the professional world. Being able to explain my programming and design decisions effectively will help make me a more successful computer scientist.*

In this final example, the participant describes the ways in which making the communication portfolio and sharing it with others can contribute to her success as an engineer.

> *The ability to reflect on your experiences and present your skills and knowledge effectively are invaluable to being a successful engineer. These activities are not recognized as valuable in the normal engineering curriculum, so having the opportunity to share and learn with other engineering students has been very beneficial.*

To summarize, these participants' comments indicate that they are thinking about the different ways that they can use communication to make things happen.

Goals for exerting power. Participants' statements regarding the goals or motivation behind their attempts to exert power through communication varied. In other words, participants described a variety of things that they wanted to make happen, ranging from very general goals (e.g., being successful) to more specific goals (e.g., gain funding for a project), as shown in the following excerpts from students' portfolios and survey responses.

In this first example (drawn from the quote at the beginning of this paper), the participant describes explicitly how having good communication skills can open opportunities to stand out and be noticed. She is making a causal connection between effective communication and negotiating a position of power within a team from which she can present herself to others.

> *Engineers that can communicate well are better collaborators, and often get more opportunities to shine, since they are usually the team member that presents work.*

In this next example, the participant alludes to the opportunity (i.e., I was *able* to divide the work—through clear communication) to make very specific things happen (i.e., change the atmosphere).

> *Without effective communication skills, a good idea could be overlooked. Another example is Yahoo! Hack-U, which is a 24-hr programming contest. Under the time constraint, clear communication and teamwork are necessary among team members. I was able to divide the work, integrate my part with others and change the atmosphere to one that was both enjoyable and memorable.*

In this last example, the participant describes specific outcomes (e.g., gain funding, convince others, prove something is worthwhile) that engineers might desire and asserts that effective communication will empower them to achieve these outcomes.

> *In the work place, an engineer needs to be able to gain funding or approval for various projects, convince others that a design or solution is optimal, or prove that it is worthwhile for the company to devote its resources to a particular pursuit. The audience in these situations is likely to allocate only a small portion of time to the engineer. Thus, effective communication is critical.*

In summary, these examples seem to indicate that the participants have rather sophisticated notions of the goals that they can achieve with the power that can exert through communicating effectively.

Extent of power exerted. Participants' statements also varied in terms of the extent of the power they can use through effective communication, ranging from affecting self to exerting influence over groups of people and their environments.

In this first example, the participant describes the impact of effective communication on the life of an individual. So, while the extent described is small, the impact is large.

> *Good communication skills are necessary in all walks of life. The lack of effective communication skills has a negative impact on the personal as well as professional life of a person.*

In this next example, the participant discusses how her communication abilities allowed her create opportunities for her to impact her team members and the worked they were engaged in.

> *Even though the tasks were split based on our strengths, I needed to have clear and effective communication to ensure that everyone was on the right track by playing their strengths and helping each other with areas that they were weak in. I also needed communication for integrating all our parts into a working system.*

And, in this final example, the participant describes several groups (e.g., coworkers, clients, stakeholders) that she can impact through effective communication; and, further, she implies the ways in which her influence could move them to action (e.g., responding to more interesting pitches, staying in-the-know).

> *My ability to write and speak effectively for different audiences will help me better collaborate with my coworkers on projects, and add life and interest to technical subjects when pitching to clients and investors. The people invested in projects that I work on will stay in-the-know with clear, understandable updates relevant to their interests in the project.*

In summary, these examples suggest that participants are thinking about the various persons and processes that they can influence by communicating effectively and that the impact they can have is often profound.

Breadth

Our working definition of breadth refers to students' thinking about what counts as communication for practicing engineers. Two themes emerged from the portfolio and survey data: (1) importance of breadth, and (2) mastery.

Importance of breadth. Participants all engaged in discussions about the importance of mastering a variety of communication skills—some simply addressed written and oral, while others looked more broadly. The following excerpts from participants' portfolios and survey responses offer illustrations.

In this first example, the participant acknowledges the importance for engineers to be proficient in different modes of communication.

> *In addition to being proficient at written communication, an engineer must also excel at visual and oral communication.*

In this next example, the participant describes the ways in which interpersonal communication and leadership roles can count as evidence of preparedness to communicate as an engineer and

reflects thinking beyond written and oral communication. The actual artifact (photograph) represents the communication skills that the participant engages in during her leadership roles.

> *The first picture shows the New Year party with foreign students from UW. I was in charge of the communication with teachers and foreign students…I tried to discuss with my classmates on the different types of shows and encouraged them to perform at party.*

In the following example, the participant discusses how important it is for engineers to learn how to communicate through different media, in this case paper prototypes and usability tests. This example suggests that the participant has a fairly broad view of the types of communication engineers engage in.

> *I have learned many aspects of communication that I had never thought before. I realized how important of this competency. I have learned that a effective communication is needed during the engineering process from start to the end. The communication do not have to be talking directly to other people but also communicate through the medium. The paper prototype and usability test are a good example of other aspect of communication.*

In summary, these examples reveal that participants thinking broadly about the types of communication they have engaged in that have contributed to their preparedness to communicate as a practicing engineer and, further, that communication skills are very important in the workplace.

Mastery. Participants describe the various communication activities that they have engaged in, and some describe the particular competencies that they have mastered, as illustrated in the following excerpts from portfolios and survey responses.

In this first example, the participant describes in her experiences communicating in different modes and media and the importance of that communication to her groups' work.

> *A game capstone project "Paint bomber" is a good example of how exchanging thoughts and ideas with others was crucial to the game design process and very beneficial. I had to explain and describe our ideas to the rest of our classmates visually, first through sketches and then with prototypes.*

In this next example, the participant discusses the different communication strategies she uses in her work with an autistic child, noting the need to work in a visual mode and what her solutions are within that constraint.

> *It is also extremely important to be able to communicate in a way that makes sense to the particular child. For example, Anna struggles with processing auditory information, so explanations must be systematic, as simple as possible, and concise. This method of communicating is a learned skill, and one that has taken me a long time to master. Working with Anna also requires the significant use of alternate explanations. A lot of the*

time, a particular concept will be completely lost on her if it is introduced verbally, but a pictoral and algorithmic explanation will be entirely effective.

In this example, the participant reveals a sophisticated notion of the complementary use of the words spoken at an oral presentation and the content on accompanying slides.

My slides are simple and include only a small amount of text because they are meant only to support my oral presentation. The audience is reminded of the key points of my talk, but is not overwhelmed with unnecessary text because they would be unable to both read busy slides and fully take in my talk. As I gave my presentation, I interacted with the slides by referencing the key points explaining each figure.

To summarize, these examples reveal that participants are engaging in a variety of communication activities and the examples suggest that participants are focused on mastery of different communication skills and are aware of their importance for professional practice.

We turn now, in our breadth analysis, to our examination of the artifacts themselves.

Artifacts. As we described in the earlier results section (extent), we catalogued the artifacts in two ways: (1) whether or not they went beyond traditional written documents and (2), whether or not they were drawn from experiences outside of school.

As noted earlier, all five participants included artifacts that were not traditional written documents. Examples of these artifacts include the following: photographs of team members, tutoring experiences, and volunteer events; PowerPoint decks and posters for courses and symposia; screenshots of a program interface; video prototype; and teaching award. Examples of written documents presented as artifacts include the following: written outline, purpose statement for graduate school, engineering lab report, technical paper for a symposium, and written report for a communication class.

Also as noted earlier, participants, for the most part, tended to confine their considerations of evidence of preparedness for professional communication to school-related experiences. However, one participant refers to the importance of drawing widely from past experiences and two participants provide artifacts that are drawn from experiences outside of traditional coursework. These artifacts included a technical paper and oral presentation for a professional student symposium, photograph of a participant and the autistic child she tutored, and several photographs of volunteer events that the participant was involved in.

Discussion and Conclusions

In this work, we are exploring the issue of how engineering students conceptualize communication—specifically in terms of situatedness, empowerment, and breadth—as part of a broader effort to understand engineering students' preparation for communication as practicing engineers. This study is a first attempt to investigate these issues by examining how a group of five students wrote about communication in the portfolios that they created in an interactive studio setting and how they responded to survey questions asking about their experiences

creating the portfolios. This work involves reasoning from how students talk about their notions of communication, to forming ideas about their underlying conceptualizations.

Specifically, we asked the following question: to what extent and in what ways do these five students' portfolios and survey responses include or reflect situatedness, empowerment, and breadth with respect to communication?

In terms of extent, we found that each of the five participants touched on situatedness, empowerment, and breadth within their portfolio and some of the students brought these issues up in their survey responses. It was not unexpected, given the task of creating a preparedness portfolio on communication, that the participants would engage with situatedness on some level. However, we were pleasantly surprised to see so many references to empowerment in the participants' texts. Regarding breadth, we were not surprised to see that the participants were thinking broadly about different types of communication and that some were thinking beyond school for evidence of their communication skills.

In terms of the ways in which they addressed the dimensions, several notable things came out. For example, regarding situatedness, we anticipated that students would talk at some level about the importance of considering audience. However, what we found intriguing was the variety in the level of depth to which students considered the entire communication context (i.e., audience, purpose and use). Further, students' statements that explored context fully, often also hinted at understandings of empowerment through communication. We were pleased to see how many students made fairly strong statements about the ways that effective communication can bring about actions—whether statements about the empowering nature of communication in general or whether they were specific statements about their own use of language to make things happen. With respect to breadth, most students talked about the importance of being proficient at different forms of communication, typically written and oral. However, some students thought very broadly about what counted as communication—discussing their volunteer work, teaching skills, and integrating different media to get ideas across.

So what do we know from students' statements about their underlying conceptualizations of communication? As researchers, we need to be cautious in interpreting our findings for at least two reasons. For example, an absence of information in the portfolio or survey responses is difficult to interpret (i.e., just because someone did not talk about something in the portfolio does not mean that they do not know about it). In addition, just because someone talks about something does not necessarily mean that what they say is core to what they believe. For example, students in our studio sessions could have discussed items in their portfolios based on conversations that they had with each other but not yet internalized. Nevertheless, our analysis suggests that these five students are all thinking about situating their communication, about using their communication to effect action, and about the importance of being competent at many different forms of communication. Further, the analysis suggests that the students have quite different ways of thinking about all of these issues. This is inspiring to us and, we believe, important for educators to know about.

What do we think about the transferability of our findings? Admittedly, these five students selected communication as the competency they wanted to focus on. The demographic data in

the appendix show that all of the students felt that communication was very important for becoming a successful engineer. So, one could say that these students are ones who might be even more interested in developing excellent communication skills than the average engineering undergraduate. However, not all of the students rated themselves highly for communication skills. So, from this perspective, our participants may be fairly representative of engineering students in general.

So, what does this work suggest for the future? This study was a preliminary study intended to give us a look at students' conceptions of the communication of practicing engineers in preparation for a portfolio studio series that we ran during winter of 2011. In that study, which we just completed, we worked with a larger group of students and collected more comprehensive data on their conceptualizations as well as data on their motivations concerning communication and their self-efficacy relative to communication.

These results of this preliminary study reported here have the potential to at least stimulate conversations concerning engineering communication instruction. For example, in what ways do current instructional practices take into account the extent to which students in their classes may have the kinds of complex and varied conceptualizations about communication that we noted in this work? In other words, are we possibly underestimating our students' understandings of communication? Are we fully honoring what they bring to the communication class? Are we allowing space in our curriculum for students to examine their past experiences and make meaning of them in light of preparing themselves for the communication of practicing engineers?

Looking beyond the issue of students' conceptualizations per se, we are excited about the portfolio studio process more generally. Not only do the portfolios that students create help us as researchers and educators understand what the students know, the process seems to help the students develop even more sophisticated, integrated notions of communication as well as increased motivation and self-efficacy with respect to communication.

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Appendix

Table A-1. Participants' self-ratings of public speaking ability and communication skills relative to peers, ratings of the importance of public speaking ability and communication skills to becoming a successful engineer, and ratings of their familiarity with the activities of practicing engineers.

	Babette	Lindsey	Courtney	Jessica	Ming
Perceived public speaking ability (compared to class-mates, on 5-point scale)	Average	Highest 10%	Above average	Average	Highest 10%
Perceived communication skills (compared to class-mates on 5-point scale)	Average	Highest 10%	Above average	Highest 10%	Highest 10%
Importance of speaking ability to success as an engineer (4-point scale)	Very important	Very important	Very important	Very important	Somewhat important
Importance of communication skills to success as an engineer (4-point scale)	Crucial	Crucial	Crucial	Crucial	Very important
I am familiar with what a practicing engineer does (4-point scale)	Agree	Strongly agree	Agree	Neither disagree nor agree	Neither disagree nor agree