

## Research Article

# New Engineers' Transfer of Communication Activities From School to Work

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**Abstract—Background:** Communication is critical to engineering work, and despite its emphasis within engineering education, it is still noted as a gap in new engineers' preparedness for work. **Literature review:** Prior research points to communication gaps among new engineers. Few studies have extensively examined transitions between academic and professional engineering contexts. Work remains for understanding how new engineers transfer communication skills. **Research questions:** 1. In what ways do new engineers transfer communication practices from school to work? 2. What challenges do new engineers experience in moving from communication as practiced at school to communication as practiced at work? **Research methodology:** This study presents a thematic analysis of data from weekly reflections and regular semistructured interviews conducted during new engineers' first year of work. **Results and conclusions:** Despite relying heavily on academic experiences involving both documenting and presenting technical work, new engineers report experiencing communication-related challenges. While further attention to communication activities can be given within engineering curricula, the complexity and situated nature of communication in the workplace cannot be fully replicated in the classroom. As new engineers move between school and work, they experience challenges adapting to a new environment including communication activities embedded within unique sociocultural contexts. While the classroom cannot fully replicate these professional settings and all of their nuances, students can be made more fully aware of the embedded nature of communication activities. Moreover, engineering educators can simulate aspects of the workplace in capstone courses, and companies can provide guidance to help mentor new engineers through the inevitable context gaps.

**Index Terms**—Capstone design, engineering communication, knowledge transfer, workplace communication.

Communication has been part of engineering curricula since the late 1800s [1] in a variety of forms [2], but decade after decade, government and industry reports as well as research studies cite communication as a major gap in new engineering graduates' preparation for work. In 2013, the American Society of Mechanical Engineers listed "Greater expertise in professional skills of communications, leadership, and creativity" as one

of the drivers of their Vision 2030 project to define the future of mechanical engineering education [3]. In 2018, Brunhaver and colleagues [4] noted communication as one of several professional skills early career engineers reported as both critical to their work and missing from their undergraduate education. These and dozens of other reports and studies tell the same story: despite stand-alone courses in technical communication and disciplinary courses with integrated communication teaching, a gap between school and work persists.

In this study, we turn from questions about whether the gap persists to questions about *why* it persists—and by extension, what both engineering programs and engineering workplaces can do to help close it. In particular, we focus on new engineers' communication experiences as they transition from capstone design courses to engineering workplaces, using data from the Capstone to Work project. To inform communication and engineering educators as well as engineering professionals who work with recent graduates, this project followed more than 100 engineering students completing project-based capstone design courses from four different

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## Practitioner Takeaway

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- Although capstone courses provide students with effective communication instruction and experience, the complexity and situated nature of communication in engineering workplaces cannot be fully replicated in the classroom, resulting in inevitable context gaps.
  - New engineers still need to learn the individualized norms and expectations for their new workplace environment.
  - Companies hiring newly graduated engineers can help with workplace transitions, especially if the onboarding process encourages new engineers to draw upon prior educational preparation, particularly capstone experiences.
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institutions from graduation through their first year of work. Through extensive surveys and interviews, this study examined the ways that graduates did and did not transfer learning across contexts.

Although multiple studies have examined engineering students' communication experiences at school and professional engineers' communication experiences at work, few have offered extended explorations of the transition between contexts. To address this gap, we draw on Dias et al.'s landmark study [5]. We use their framing of writing as a situated activity to explore two research questions.

**RQ1.** In what ways do new engineers transfer communication practices from school to work?

**RQ2.** What challenges do new engineers experience in moving from communication as practiced at school to communication as practiced at work?

The next section overviews related prior research to help situate this study within the larger conversation, examining the role and transfer of communication skills to engineering workplaces. Following the literature review, the study's methods, results, and implications are shared.

## LITERATURE REVIEW

To situate this study, we briefly highlight three key strands of prior research:

1. Studies exploring the prevalence and value of communication in engineering workplaces, along with the relationship between communication competencies and success in the engineering workplace
2. Studies examining the differences between the writing of engineering students and that of engineering professionals

3. Studies investigating how or whether communication skills transfer across contexts and whether transfer of rhetorical knowledge may be facilitated

### Communication in Engineering Workplaces

Multiple studies spanning decades repeatedly demonstrate that a significant portion of an engineer's workday is spent communicating. Passow and Passow (2017) found multiple studies indicating 30% to 40% of an engineer's workday is spent on writing [6]. When the scope is broadened from writing to include oral communication activities, time spent increases to more than half of an engineer's workday. These findings align with earlier works surveying newly employed engineers who reported the prominence of communication among their daily activities [7]–[12]. From these prior studies, we know that new engineers should expect communication to factor significantly into workplace tasks.

Other works investigating connections between workplace competencies and educational outcomes help to support the value in new engineers successfully transferring communication practices from academic to professional settings. A 2016 study of STEM workplace competencies [13] used the Department of Labor's job-specific information database to analyze educational frameworks and found communication-related skills among the most important competencies. In addition, two activities—getting information and communicating with supervisors, peers, or subordinates—were within the top five most important work activities. Earlier work by Passow [14] analyzed the ABET competencies that engineering graduates found most important to their work and identified communication within the top cluster of necessary competencies. Other works [7], [15], [16], although more narrowly focused on a specific engineering discipline, also reported communication to be

among the top areas of importance by surveyed professionals. As the trends from these studies confirm, the successful engineer is one whose communication skills can work in concert with technical abilities.

### Differences Between Students and Professionals

Despite the prevalence of both stand-alone and integrated communication courses in engineering curricula, several studies highlight important differences between the communication practices of students and professionals. These differences suggest that new engineers, despite their communication preparation, cannot expect to seamlessly participate in workplace communication activities. Challenges shifting from communication at school to communication at work may await them. Winsor's longitudinal study of students moving between school and co-op placements highlighted the rhetorical differences across contexts [17]. Wolfe's work also points to differences between school and work [18]. Conrad's 2017 linguistic analysis [19] revealed differences between school and work writing with student writing featuring less linear organization, containing problematic style elements, and including more sentence-level errors than practitioner writing. Although communication courses may be designed to include real-world projects for a workplace audience, fully replicating workplace communication in a university setting remains a challenge, as Paretti [20] explains using activity theory.

**Knowledge Transfer Studies** Prior knowledge transfer studies allow better understanding of how new engineers apply communication learned in school to their roles at work. Although Katz's 1993 study [21] examined knowledge transfer in an industrial setting with a close-up view of the entry-level engineer, the majority of previous studies focused on transfer from one academic setting to another [22]–[26]. Few studies have investigated how (*or whether*) new engineers successfully combine communication skills learned in the classroom with awareness of the links between general communication practices and context-specific norms in their particular workplace cultures.

Earlier research revealed that although knowledge transfer of communication skills can be facilitated through pedagogical approaches informed by situated learning [19], [24], [26]–[30], new engineers do not necessarily learn rhetorical awareness immediately. Prior works [31], [32] indicate that

students often view writing as a discrete and objective skill rather than one that is tied to context and includes broader rhetorical strategies such as persuasion. Leydens' study [27] involving engineering students and professionals identified multiple stages on a continuum of rhetorical awareness. Student participants embodied characteristics of the earlier continuum stages, in which writing was arhetorical and writers merely conveyed data, while the last stage of full rhetorical awareness was realized only by engineering professionals with considerable workplace experience. With limited studies focusing on how new engineers transfer communication training from school to professional settings, we lack insights regarding what skills they transfer and what communication-related challenges they face.

### RESEARCH QUESTIONS

These studies point to the complexity of transferring communication practices from school to work and, given the centrality of communication in engineering practice, point to the need for a deeper understanding of what and how new engineers do and do not transfer across contexts. To further our knowledge about transfer of communication activities between academic and professional engineering environments, our study addresses the following research questions:

**RQ1.** In what ways do new engineers transfer communication practices from school to work?

**RQ2.** What challenges do new engineers experience in moving from communication as practiced at school to communication as practiced at work?

Notably, by “communication” we mean not only formal written documents, but the full range of written, oral, formal, and informal communication practices that occur at work. This broad definition is warranted because both the studies of workplace competencies noted previously and studies of communication in engineering workplaces [33], [34] consistently apply a similarly broad frame.

**Conceptual Framework** To address these questions, we draw on Dias et al.'s work [5] exploring differences between academic and workplace writing. They utilize several frameworks to highlight the situated nature of writing. Two of their frameworks guided our work.

- **Rhetorical Genre Theory:** Genres—regularized organizational and discursive structures of

texts—emerge in response to recurrent social situations. Genres are not simply arbitrary formats, but formats entwined with audience and purpose. Moreover, these situations are local, not general, because social situations are themselves always locally contextualized. In terms of our study, for example, an “engineering report” for a course, where it must demonstrate learning outcomes, may look different than a report for Company A or Company B, where different standard templates and organizational needs may apply.

- **Activity Theory:** Rather than looking at texts as products, as they often are in school, activity theory provides a way to see writing as an activity embedded in a nexus of actors, motives, communities, and rules. Activity theory provides a system-level view including contextual factors concerning the way work is divided, and the formal and informal rules of a group or organization. At work, communication is often a tool that mediates work rather than an end-product in itself.

## RESEARCH METHODOLOGY

As detailed in our previous Capstone to Work publications [35]–[37], this study stems from a larger longitudinal multi-institutional mixed methods study. Participants were recent engineering graduates from four institutions, each with well-established project-based, industry-oriented capstone programs. During participants’ first three months of work, qualitative and quantitative survey data were collected weekly. In addition, participants were interviewed four times: upon completion of the capstone course (prior to starting work), and at intervals of 3, 6, and 12 months on the job.

**Participants and Sites** A total of 132 participants from two different graduating classes (referred to as Cohort 1 and Cohort 2) from three Mechanical Engineering capstone courses and one Engineering Science program were recruited from four sites. Of that number, 119 participants (57 in Cohort 1 and 62 in Cohort 2) began work and continued to participate in the study beyond the background interview. Mechanical engineering was selected as the primary discipline to provide literal replication [38] across study sites because it represents one of the largest and broadest engineering disciplines, with a high percentage of graduates entering industry. The Engineering Science program provided theoretical replication [38], offering a contrasting case against which to test findings.

Although the capstone course sizes at these sites range from a small program averaging 40 graduates per year to a program graduating over 400 students per year, the programs are similarly consistent with capstone design education trends [39] in their emphasis on team projects. Each program requires at least two semesters of capstone design. Within their capstone teams, students were advised by course faculty, a course coordinator, and individual faculty and/or industry mentors specific to their project. The capstone experiences emphasized professional practices including design process, technical skills application, communication, and teamwork. Course deliverables included multiple written reports, oral presentations, and product demonstrations.

Recruitment and data collection were approved through each site’s institutional review board (IRB). Recruitment relied on capstone course visits, followed by emails inviting students to complete a screening survey capturing self-reported demographic data and information about participants’ career plans. This dataset included 52 females and 67 males. Seventy-five participants self-identified as Caucasian, 19 as Asian or Asian American, 14 as underrepresented minorities, and four as Middle Eastern; seven participants did not disclose their race.

**Instruments** To provide a rich and triangulated dataset, the study included multiple instruments: quantitative surveys informed by Experience Sampling Methodologies [40], [41], reflective surveys, and interviews. Reflective surveys and interviews were conducted by graduate research assistants close in age to the majority of the participants and with no affiliation to the participants’ capstone course. The interviews followed a semistructured interview protocol to provide common data and allow for exploration of potentially salient but unanticipated topics. In-person background interviews were designed to understand participants’ capstone experiences and related educational or other work experiences, and to identify participants’ expectations about work. Participants were assured that their responses would have no bearing on their final capstone grade, and only research team members who were not course instructors had access to the key linking participant ID to participant name.

Subsequent phone or video interviews were conducted at approximately 3, 6, and 12 months of work. These interviews explored participants’ typical responsibilities, perceived preparedness,



challenges and accomplishments, similarities and differences between capstone and work, and the ways their capstone experiences did and did not prepare them for workplace roles. The protocol also included prompts tailored to follow up on issues participants reported in previous data. Full protocols are available [42].

This study presents a secondary analysis of the reflective survey and interview data. Findings from the quantitative data, which report the activities that participants did each week and their perceived preparedness, have been reported in detail elsewhere [35], as have findings from the initial qualitative data analysis [37]. For context, these findings are briefly summarized at the beginning of the Results and Discussion section of this article.

The weekly reflective surveys, administered during the participants' first 12 weeks of work, were designed to elicit thick and rich descriptions of participants' most significant challenge or accomplishment and the role that their capstone experience played in preparing them for that experience. The questions varied slightly based on whether the survey addressed a challenge or accomplishment, but followed the same basic format each week, as follows.

1. What was your biggest challenge this week?
2. What made it so challenging?
3. How did you approach this challenge?
4. To what extent did you feel prepared for this challenge based on your capstone design experience? Based on other experiences?
5. Is there anything you think your education might have done that would have better prepared you?
6. Are there any other workplace activities this week that you felt particularly well or poorly prepared for? If so, please explain.

Participants received compensation for each interview and survey completed. To increase retention, participants were permitted to skip data-collection points; they continued to receive invitations to complete surveys unless they specifically chose to discontinue participation. Of the 119 participants who began work, 110 completed reflective journals, 82 completed 3-month interviews, 81 completed 6-month interviews, and 71 completed 12-month interviews.

**Data Analysis** As noted, this study presents a secondary thematic analysis of the qualitative data (reflective journals and interviews) only. To situate our work, we briefly describe the primary analysis

of this data, which has been previously reported in more detail [35]. The primary analysis focused on identifying and categorizing the challenges that new engineers encountered in their transition to work as well as areas of transfer between school and work. This analysis began with an *a priori* coding scheme informed by Lutz and Paretti's [43] study of student learning in capstone design, which identified four major categories: technical work, teamwork and communication, self-directed learning, and identity development. Subsequent emergent codes included one additional major category ("adulthood") as well as subcodes within each category to provide a more detailed understanding of participants' experiences.

Table I presents the Teamwork and Communication subcodes and their definitions, along with examples identified as Challenges. In addition to these codes, segments were also coded by type, as listed in Table II, to illustrate the differences across types. Examples are drawn from segments coded as Interpersonal—General.

Research team members, who were not capstone instructors, completed primary coding. To achieve interrater reliability, team members were trained and normed on the codebook, which was developed iteratively through multiple rounds of review. After coding a common set of documents, team members met to discuss discrepancies and achieve consensus, then updated code definitions as needed. Research team members, who were capstone instructors, participated in the review of these definitions, comparing coded segments to definitions to clarify and refine the codes as needed.

As noted, findings related to primary codes (Tables I and II) have been published previously. Effectively, this primary analysis and subsequent publications [35], [37], [44] focused on "what"—that is, what challenges did participants experience and what did they transfer from school to work? The secondary analysis presented here turns to questions of how and why. Authors Ford (a capstone course instructor) and Paretti (not a course instructor) conducted a thematic analysis of excerpts tagged with any of the teamwork communication subcodes, guided by rhetorical genre theory and activity theory, to understand both how new engineers transferred practices from school to work and why transfer may not have occurred or may have been challenging. This thematic analysis focused on teamwork and communication activities (Table I) that were coded as challenges, successful transfer from capstone,

TABLE I  
TEAMWORK AND COMMUNICATION SUBCODES WITH DEFINITIONS

| Teamwork and Communication Subcode | Definition: Activities Associated with Working in Teams or Communicating Clearly, Including ...      | Example Quotations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------------------------------------|------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Client Meeting                     | ... ..meeting with customers, clients, or other external stakeholders                                | Changing things last minute. Well, the product manager on their side often will, and especially recently, will just kind of flood us with all these questions and "Go check out this, go look at that, go do this," to the point that that will take up the vast majority of the week, and then we're starting to fall behind on the actual projects. And so that slows things down more, and he doesn't seem to realize that that's what's happening, even though we've kind of pointed to it multiple times. And often, I guess the frustrating thing is he... A lot of times what he's asking is something we've already covered and so sometimes it's easy as just like forwarding him our weekly charts from two weeks ago and reference slides six through nine or something. (12-month interview)                                                                                                                                                                                                                                             |
| Formal Presentations               | ... developing or giving a formal presentation                                                       | It's kind of crazy to see how you want to get one thing approved on a car. Well, it's going to take ... You're going to have to present it in about seven different meetings, the same exact topic. It's a very long strenuous process, you're going to have everything in an exact format. (3-month interview)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Informal Presentations             | ... developing or giving an informal presentation (e.g. to coworkers or supervisors)                 | That is with the performance reviews that I do. Those are operators that I'm presenting to. If I misspeak, or if I calculated a number wrong, those guys are very competitive with each other because, like I said, there's five different crews and they're all doing the same thing. So obviously, they want to be the best, and if I accidentally mess up the number of something, they're very passionate about it, and they definitely let you know that you're wrong about it, even though they didn't do any of the data analysis, but they know if they worked their butt off. (3-month interview)                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Informal Writing                   | ... writing any type of informal document (memos, emails, etc.)                                      | I think emails can definitely be misinterpreted. And also [my supervisor] said to be crisp and concise, when addressing customers so that there's no misunderstanding or misconstrued information. (6-month interview)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Interpersonal - General            | ... communicating or interacting with others in the workplace (e.g., colleagues)                     | Oh, the other thing that I was not well prepared for was just the interpersonal skills of communicating with older males who are from the south. And it's just different than what I'm used to, just culturally. Trying to relate to them was sometimes fairly easy, but sometimes it was a little more difficult because they have just a different way of speaking and different, and this could be very well just because we're different people, not because they're from the south or older males (6-month interview)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Interpersonal - Manager            | ... communicating or interacting with a manager, supervisor, or others higher up in the organization | After I write a work order, it gets sent to [my manager] before it gets sent out to everybody else for approval. So I have to ask him to make a change and inform him, so when I come to him and say "Hey, this head lamp is gonna have a connect change, I wrote a work order for it." He's gonna sit there and grill me on why is this gonna be a change and when is gonna happen? What issues could arise if we make this change? All this sort of stuff, whereas with my previous job there was pretty much no need unless I had a question on how to do something. I rarely ever saw my manager because it was a by the book job. (12-month interview)                                                                                                                                                                                                                                                                                                                                                                                          |
| Leadership                         | ... acting as a leader                                                                               | ...I think it's because I am taking on much more responsibility that I don't necessarily enjoy doing. Maybe everyone wants to get at this point where they are able to make a decision, right? Or [inaudible]. My role, being a scrum master .... You have to empower teams to make the decision. You can't make the decision. It's not like, for example, if you are like a product manager or a product owner (those two roles are kind of interchangeable in my company right now), but you set priorities for the team. (12-month interview)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Project Planning/Logistics         | ... organizing work among members of a team                                                          | Yeah so ... for a development project, we're ... last week we did a really big planning intensive. And so some of it I don't think everyone's totally in line with yet, but I knew where we needed to hit for our design freeze. I was like, "This is where we stop working and automation comes in and takes our design and makes it so it gets the right machines. I don't know what we do after that," and then they're like, "Oh that's where a lot more of our heavy documentation, our validation, and our human factor studies come in." And that I just ... even with all the context of how projects run, I didn't have a good feel for it yet of what was happening before then and what was happening after. And I think some of that was how the projects communicated, but also some of it's the school that you only look at ... even in senior design we're looking at an eight month chunk of time, so there's just not the practice of scheduling out for more than that. (3-month interview)                                       |
| Team Function                      | ... discussions of how a team is working                                                             | <p>Why would a meeting be stressful?</p> <p>[Participant]: Tight timelines and things that come up that we know are going to delay timelines, that's the biggest thing.</p> <p>Interviewer: And then, when something like that happens, you try to refer to the facts and less to your emotion.</p> <p>[Participant]: Yep. And kind of catering it to who's in the room. I think it really depends on who is in the room. Sometimes people just need to know what are my action item, sometimes people are a little bit more emotional, and they need to talk through things a little more, than kind of come to terms with whatever the outcome needs to be. And they need to get down into the details, some people don't care about the details. So it's a variety of different people and I've also seen that done here and also I've seen that done through internships, a lot. Everyone has a different style and it's really important if you're leading a discussion to cater that discussion to who is in the room. (6-month interview)</p> |
| Team Meetings                      | ... conducting or participating in a meeting                                                         | I think just because I've never really done it [being professional in large team settings] before, I've done it enough to not be walking around blind, but I still feel like I don't know ... We'll have meetings, and I don't really know what to say or how to contribute, but it's changing now. As I'm, I guess, maturing in my role and I'm starting to gain, I don't know if it's confidence, in my knowledge or whatever that is, but it's kind of the start of a transition. (3-month interview)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Writing Reports                    | ... writing formal documents such as reports                                                         | The thing I felt least prepared for is we had a sponsor meeting with several different big sponsors of the [inaudible 00:19:37] office and all of the national labs, whatever, were there and I was asked to take notes, which wasn't a big deal. That was fine. But then afterwards I was asked to prepare a meeting summary and I had no idea what that was. And ... I mean, basically it's exactly what it sounds like but I wasn't sure if they wanted a description of what happened, my cleaned up notes, things like that meant to them. Because my cleaned up notes were like 20 pages long. This was a six hour meeting. (6-month interview)                                                                                                                                                                                                                                                                                                                                                                                                |

TABLE II  
TYPE CODES\*

| Type Code                         | Definition                                                                                                                                                                                                             | Example Quotation (Interpersonal—General)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Workplace Experience or Event     | The participant is describing an event or experience that happened at work, without suggesting that it was a challenge or an accomplishment.                                                                           | So, once I approve a project, I have to get all their paperwork and all of the required information into us in order to get their permit issued. So, I've had to deal with that several times on projects so far. I've had a couple projects where maybe this developer hasn't really done any work with us in the past, so they don't know the process as well. I had to walk them through it a little more. Which was good because then I got to learn it a lot better too.                                                                                                                                                                                                                                            |
| Accomplishment                    | The participant is describing the activity as a significant accomplishment.                                                                                                                                            | I feel like I have a pretty good relationship with a lot of people that I've met and worked with to where, if at any point I get stuck or need some help, I don't feel out of place to go up and ask them for some guidance or some information that maybe missed up or something like that. So I think, yeah, just having a good relationship as well as being able to sit there and learn with people and how they do things is very beneficial. (12-month interview)                                                                                                                                                                                                                                                  |
| Challenge                         | The participant is describing the activity as something they found challenging.                                                                                                                                        | there is one guy in my group who I'm pretty positive he preferentially withholds information from me because it gives him a chance to have a leg up in the next meeting. And look good for going above and beyond what he was supposed to do. But, really, it's like something he should of shared with me because I had time to work on it and basically it's like that's kind of my role on the team ... Is to do that kind of ... Not busy work, but ... the stuff that he comes up with, "I don't really have time to do this, [[Participant]] can you handle this?" But, instead, he'll not mention it at all, not thinking he needs help and try to get recognized for going above and beyond. (3-month interview) |
| Strategy                          | The participant is describing the activity as a strategy they used to meet a challenge or succeed at a task.                                                                                                           | it was just doing more work with them than I had done before. I've had to work with them much more time period you know like and the factory working on maybe a tool or something. You get to actually talk to them more about other stuff. Like we're talking about personal stuff. When you get to know them outside of work, you get to know them better like as an actual person too and I think that's been helpful. (6-month interview)                                                                                                                                                                                                                                                                            |
| Successful Transfer from Capstone | The participant describes the activity in terms that indicate transfer of learning from capstone to the workplace—i.e., the experiences are similar, or the participant used knowledge from capstone in the workplace. | I guess another valuable thing is having the peer reviews was definitely helpful 'cause I know that in the past I probably took feedback as criticism. So, having that feedback from my peers and my professor was kind of like ... Took that wall down and taking feedback as it is, which is feedback and ways of developing yourself and improving yourself 'cause I enjoy feedback now. I always ask people for feedback and if there's any way that I can improve. So, kind of opening myself to that 'cause I definitely see other people that don't take feedback well and I kind of see their growth kind of stalled because of it. (12-month interview)                                                         |
| Difference                        | The participant describes the activity in terms of a difference between school and work.                                                                                                                               | Well, the team is definitely bigger and we're even like spread out even across the country. So a lot of times I'm working with an account manager, or a sales rep, or even an engineer that's not even in the same state as me. So, that access to contact is a lot different. It's a lot more phone calls, and video calls, and emails, and stuff of that nature. Whereas I was on a team of only five people and it was kind of like if we needed to get together, it was just like a meet at the library at whatever time or meet at the Senior Design lab. So, that's a lot different. (12-month interview)                                                                                                          |
| Capstone Advice                   | The participant is providing advice for the capstone course (e.g., to better align it with work).                                                                                                                      | I would probably say one, focus on how to make it work with the different people on your team and try to identify what helps you work with specific others. Like if somebody has a specific work style maybe different than other team members, how you can play into that to help you work with that person, because I think that's big part of especially my job. Interfacing with different groups, there's different ways I go about interacting with the different groups I think here at work, so I think part of that is just the different cultures and the different areas and the different I guess processes and how work actually gets done. (3-month interview)                                             |

\*Note: Because of the focus of the prompts, the reflective journals used only the challenge, accomplishment, and strategy codes, with "Transfer from Capstone" as a subcode within Strategy.

and differences from the capstone experience (Table II). Themes were developed through multiple rounds of review and discussion of the coded segments. The resulting themes, with illustrative excerpts, are described next in detail.

## RESULTS AND DISCUSSION

### Summary of Previous Work (Primary Analysis)

To situate our findings, we briefly summarize key patterns with respect to participants' workplace communication based on quantitative and reflective surveys from Cohort 1 conducted during the participants' first 12 weeks of work, as reported in [35], [37], and [42]–[45]. (Unpublished findings from Cohort 2 show no major changes in these patterns.) Like the engineers in most other workplace studies (e.g., [4], [6]–[16]), our participants engaged in communication activities routinely. They frequently participated in team and client meetings. In addition, planning and participating in presentations and written documentation were regular weekly activities.

At the same time, despite previous studies foregrounding lack of communication skills among new engineers, our participants rated their level of preparedness for communication tasks relatively high over their first 12 weeks of work; presentations, report-writing, and team meetings were among the activities participants felt most prepared for, rating themselves on average as 6 on a scale of 1-7, with 7 being fully prepared. Equally important, however, participants frequently cited teamwork and communication activities as their most challenging experiences, with 91% of participants citing a significant challenge in this category at least once during the same time period. That is, while participants felt prepared for many of the communication experiences that they faced, they also recognized substantial challenges in this area. Finally, perhaps most relevant to our current investigation of transfer, in meeting challenges in communication and teamwork, 74% of participants reported drawing on capstone experiences for guidance during their first 12 weeks of work. For full details on these findings, including additional details on quantitative and qualitative data analysis, as well as findings relevant to the other categories (technical work, self-directed learning, identity development, and adulating), refer to [35]–[37] and [42]–[45].

Against this backdrop, the following sections present our secondary analysis, exploring the

themes identified in our data that highlight both areas of transfer between school and work and barriers to that transfer, framed by both genre theory and activity theory. Note that although the patterns described above reflect only data collected during participants' first 12 weeks, which readily lent itself to quantification, the thematic analysis draws on data collected throughout the first year, including the interviews, where participants elaborated on their experiences in much richer detail.

### RQ1. In What Ways Do New Engineers Transfer Communication Practices from School to Work?

The participants transferred familiarity with common workplace genres and an awareness of the range of actors involved in engineering activity systems that create multiple audiences with whom they must communicate.

*Familiarity With Common Genres:* Rhetorical genre theory highlights the ways regularized formats of different types of communication are embedded in the social situations (audience and purpose) in which the communication occurs. In describing ways that their capstone experiences prepared them for work, participants identified multiple genres (format and social situation) that they had been exposed to in school that recurred at work. For example, not surprisingly, participants felt prepared for the length and scope of workplace reports expected of them, as suggested by the following excerpts.

This week I was asked to work on a very lengthy document and provide comments and recommendations for revision .... I felt prepared for this task from my experience in capstone and the technical writing that we used. [Participant #3277]

We do a lot of report writing .... is really necessary here because when the FDA comes, they have to be able to audit everything.... the emphasis ... on high quality reports and presentations definitely makes it easier to transition into this. [Participant #4128]

Similarly, participants reported the value of being exposed to presentations that moved beyond the classroom to include the kinds of client meetings that they were asked to join at work.

... the fact that we had weekly presentations to our clients, or whoever may have decided to show up, just getting more presentation skills



definitely made it so I wasn't a total buffoon week one. [Participant #4134]

Notably, across these genres, participants referenced both the form and the attendant social situation. For example, a client meeting was a familiar genre not because they had learned the structure in class, but because they had presented information to clients in the context of their projects. Thus, the industry orientation of capstone courses, which consistently created the social situations to which various engineering genres respond, was critical in supporting transfer of genre knowledge.

It is worth noting, however, that in some cases, the social exigence for certain genres was not clear until participants reached the workplace. For example, in describing project documentation as a familiar format, one participant noted,

The importance of documentation .... my god. I thought it was so useless ... it felt silly, like why do I need to write this down? It happened like two months ago, and we fixed it. It should be done, we're good, but ... this commissioning guy who had left us about a year ago did this, and what was the reasoning, and not having the documentation for it means that we have to go back out again, waste money and time, and figure out why did this guy make this pump a constant speed rather than VFD. ... Documentation is really important. I think that's the most important thing I learned from Capstone .... I didn't quite understand it at that time, but now I'm just like, damn, this is probably the most critical thing in any industry. [Participant #2171]

As this comment suggests, some social exigencies are difficult to replicate in school—in this case, because school projects have shorter life spans and student teams remain together throughout the project duration. Still, exposing students to both recurrent genres and their attendant social situations provides an important basis for school-to-work transfer.

*Awareness of Multiple Audiences With Engineering Activity Systems:* Where rhetorical genre theory provides a lens to understand the transfer of common genres from school to work, activity theory illuminates the ways that engineering work is embedded in a system of diverse actors, where interpersonal communication plays a key role. This system-level awareness provided another dimension of transfer as participants described how they leveraged their awareness of multiple

audiences to support workplace transitions. At a basic level, this transfer included simple awareness of multiple audiences.

I think that the capstone project gave us a good understanding of what the real world is like as far as presenting us with the opportunity to be able to communicate with a bunch of different people at the same time. [Participant #2166]

More deeply, however, participants also reported transferring understanding of how engineering work is distributed among various actors.

... one thing that prepared me well is working in teams ... and getting to work with our liaisons and everything. I feel like that was helpful. The whole working with other engineers on the same project and trying to work out solutions for different problems and get everybody's input. That's been helpful. [Participant #3145]

At least with my projects, reaching out to different professors that weren't in our direct field, that helped with interacting with other engineers that aren't in my department. [Participant #1109]

As these two excerpts suggest, industry-oriented capstone courses prepared students for how project decisions are negotiated among various stakeholders and rely on soliciting expertise from a range of sources. This awareness highlights the importance not only of genre knowledge, but of interpersonal communication.

## **RQ2. What Challenges Do New Engineers Experience in Moving from Communication as Practiced at School to Communication as Practiced at Work?**

Although participants ranked their preparation for communication-related tasks as high and transferred both rhetorical genre knowledge and awareness of the network of actors involved in engineering from school to work, they also identified teamwork and communication activities as areas where they experienced many of their most significant challenges, with interpersonal communication (with colleagues and with managers) most prominent, along with coordinating project plans and logistics.

Some of the challenges that participants reported reflect a lack of genre familiarity; industry-oriented capstone courses cannot cover all possible genres. Most challenges, though, are more usefully understood through activity theory. As articulated in *Worlds Apart*, "Writing practices are closely

linked to their sociocultural contexts, and writing strategies vary with individual and situation” [5, p.10]. The communication-related challenges that new engineers faced, although decreasing with time, were still experienced by more than half of participants after a year on the job, suggesting that gaining a situated understanding of their professional environment can be a lengthy process. Even though participants turned to their capstone experiences as a strategy for overcoming the challenges that they faced, because the situations were novel and context-dependent, the challenges were not necessarily easily or quickly resolved.

In particular, many of the challenges that participants experienced can be characterized by the nodes at the bottom of the activity theory triangle—the rules (written and unwritten), community, and division of labor within their specific organization. In addition to unfamiliar genres, participants reported challenges in understanding where information resides and what tools such as templates are available; learning and navigating the nuances of relationships within the organization’s hierarchical structure; and learning the unwritten yet consequential rules of the organization.

## UNFAMILIAR GENRES

Although most participants transferred their familiarity with many genres from school to work, some also encountered new genres, reflecting both unfamiliar formats and unfamiliar social situations.

The thing I felt least prepared for is we had a sponsor meeting with several different big sponsors ... and I was asked to take notes, which wasn’t a big deal. That was fine. But then afterwards I was asked to prepare a meeting summary and I had no idea what that was. And ... I mean, basically it’s exactly what it sounds like but I wasn’t sure if they wanted a description of what happened, my cleaned up notes, things like that meant to them. Because my cleaned up notes were like 20 pages long. This was a six hour meeting. [Participant #2171]

... their writing style is different than what I’m used to for college type of work. Because you’re talking directly to the government, and there’s certain wordings that you have to be careful of, being very formal, and then a lot of requirements that have to go into it, that I have to follow the guidelines very strictly. Versus in school I feel like you had a little bit more freedom in how you

wanted to structure a certain thing. [Participant #1122]

These excerpts highlight the ways that shifting social exigencies destabilized participants’ genre knowledge. Summarizing a six-hour meeting (a rarity in school projects) was itself a new scenario that made the meeting notes genre immediately unfamiliar; similarly, the specific requirements involved with government writing created a set of unknown constraints that limited transfer. Although new engineers may have prior experience with genres that they encounter in the workplace, that experience is less applicable if learned in a vacuum rather than embedded within a community.

## KNOWING WHERE INFORMATION AND TOOLS RESIDE AND WHEN TO USE THEM

Before new engineers can successfully communicate information, they need to learn what information is already available and where to find it, as well as what tools are available and when they should be used. This learning reflects both the division of labor in an organization (who knows and does what) and the rules that govern how work is done. As one participant explained,

Well maybe somebody’s already developed part of the solution to this but just figuring out who sometimes. I’ll get a little bit different information from one person than another. I don’t know people enough to know which person is right so then it goes into digging in more. [Participant #1119]

In larger organizations, work and expertise may be distributed across multiple locations, further complicating interpersonal communication, as in the following excerpt.

I guess it’s just the expectation that I deliver everything on time with the resources that I’m given. Some of the challenges that I have right now are things I’ve never encountered before. For one thing, I’m working with only one other person locally and there are like 10 other people all in ... a different city than I am. That’s where all the knowledge is coming from, all of the expertise that I need kind of to complete my job and do it successfully .... It’s really challenging trying to stay on pace with the rest of the team. [Participant #4138]

Here the interpersonal challenge of communicating with multiple people at a distance to access critical

information creates significant time constraints, a problem echoed in the following comment.

I was spending so much time meeting with people and emailing people and having to know how to get all the information I needed in one email to send to the architect and how to do it a special way. [Participant #3145]

For students used to finding information in a textbook or through a simple internet search, the complexity of gathering information from multiple people across an expansive network represents a major shift in communication practices. Equally important, these practices require not only generalized skills in communicating with different audiences, but specific local knowledge about who has what information. Even finding the template for a given genre can be complex, as one participant explained.

I did not know what that [genre] was. I didn't know how to go about doing it and I had to ask several different people if there was a template for that. [Participant #2171]

## LEARNING AND NAVIGATING THE NUANCES OF RELATIONSHIPS WITHIN THE ORGANIZATION'S HIERARCHY

New engineers face challenges navigating social dynamics between different groups. During capstone, students typically work on a team with peers, many of whom are close in age and share a similar knowledge base. On the other hand, new engineers discover just how nuanced communication becomes when embedded in a community with its own actors, each with their own experience frame and role within the hierarchical structure. In some cases, participants described the challenge of grasping the whole complex system of interpersonal relationships at work.

Well in [capstone] we were a team and we're basically, there wasn't really much hierarchy except that there was a project manager .... in the work place there's a lot more hierarchy. ... And having to understand what different positions mean. I don't know if I really have gotten to a place where I understand the hierarchy and dynamics in the work place work. So that's something that I find different and I'm still adjusting to. [Participant #3154]

Keeping track of all of the different relationships between myself and the guys on the shop floor, and kind of managing those relationships as well

as myself and the other engineers in my group, and then as well as myself and the customer, the ultimate customer, and I know it's very broad, but I think that sort of dynamic has been the most challenging thing for me. [Participant #3151]

Other participants reported more specific interpersonal communication challenges as they encounter unfamiliar communities.

The crew still needs to be there making sure things are being done right. There's a whole aspect of interacting with them that's completely foreign to me, and a lot of times intimidating and scary because they take their job very seriously as they should. They have their own kind of culture that they're used to working with and I'm not used to working ... within that culture. Combining that with the seriousness of the work it can be challenging sometimes and definitely intimidating and feeling like I'm not doing the right thing or saying the right thing can be ... in some ways it can be paralyzing. You almost just don't want to do anything because you're afraid of screwing up or saying the wrong thing even, because it's really just that sensitive sometimes. [Participant #4125]

In this case, the combination of the local culture of the participant's community and the nature of the work (the activity) create a challenging communication context. Although a generalized ability to learn community norms to facilitate effective communication may be a transferable skill, learning and following those norms in a specific context remains difficult. Moreover, as new engineers enter workplaces, the number of different communities within and beyond the organization that they need to communicate with grows exponentially, as does the complexity of decision-making.

I have to start understanding how decisions work. Whereas last time, it was just within my team. I really knew people, I knew how to respond. Whereas some other people ... I just have to cater to more needs right now 'cause I'm working with many different teams. [Participant #2202]

As this comment suggests, new engineers are learning to "respond" within a whole new set of often invisible rules as well as multiple interconnected communities, each with their own values and expectations.



This interplay between unwritten rules and local community norms also extends to individual relationships. Although communication instruction within capstone courses likely included emphasis on the relationship between one's message and audience and the resulting choices that communicators must make, successful implementation requires a well-honed ability to read individuals' expectations and preferences. Several participants pointed to the need for such ability as a key challenge in interpersonal communication.

It's been a little bit more difficult to read people, but also knowing how to communicate with them via ... phone or email or in person. People respond in frequency with different type of methods. Some people never answer their phone, but they'll answer you if you email them. Learning that type of stuff has been interesting. [Participant #4131]

I adjust ... even my language. Some people like me to be more up front and just tell them what to do. Some people think it's more aggressive. I have to cater to all of that and understand different teams' needs. [Participant #1122]

New engineers may be aware of the rhetorical complexity of interpersonal communication, but not yet nimble enough to read multiple individuals across a wide age range and adjust their communication practices seamlessly on the fly. And although the awareness itself is transferable, as suggested by the earlier discussion of participants' awareness of multiple audiences, the adaptive expertise, like any expertise, develops over time with practice. Moreover, as these comments suggest, the rules vary by person within an organization; we cannot simply teach students that "all managers prefer direct language" or "everyone over 40 prefers email." To communicate effectively in a given workplace, new engineers still need to learn the rules for each person, which inevitably takes time.

Finally, the process of learning community expectations and unwritten rules takes on still another layer of complexity when participants communicate outside their organization. As one participant explained,

Once the testing was done, we compiled the data. This particular customer just wanted the data, they don't want us to give them any kind of feedback. Well, they wanted our opinion on what went on, but they didn't want any kind of data sheets or anything like that, so we just gave them the raw data, we gave them our opinion. And

then they ran with it. Some other customers require us to give them all of the raw data, formulate plots for them, draw conclusions, it really runs the gamut, depending on what the customer wants. [Participant #2159]

New engineers thus not only need to learn the division of labor, community, and rules within their organizations; they have to quickly become adept at learning those aspects of the activity system for clients, vendors, or other organizational partners.

## CONCLUSION

This study was designed to investigate the gaps that new engineers experience as they participate in communication activities and to better understand *why* these gaps exist. As evidenced by the qualitative data that allowed new engineers to articulate their challenges in their own voices, communication can be difficult for new engineers, requiring a deep understanding of how workplace texts are part of a nuanced activity system that includes navigating relationships and rules. Communication in engineering workplaces is complex and context-dependent. Communication activities can be viewed on a continuum of situated learning. Rather than existing as discrete skills that can be readily applied in any new situation, communication activities are complex and heavily dependent upon context. Between communicating effectively in school settings and communicating effectively in workplace settings, a whole set of contextual differences involving audiences, collaborators, and politics comes into play.

To that end, the results from this study, as framed by rhetorical genre theory and activity theory, illuminate two key points:

1. How industry-oriented capstone courses can prepare students for workplace communication
2. What challenges new engineers will experience as they move from school to work

Although capstone courses provide students with transferable communication practices through socially situated genres embedded in authentic systems of engineering practice, new engineers must transfer those skills to a specific local context with its own unique genres, rules, and communities, and its own division of labor, often distributed across locations.

As a result, the gaps that this study's engineers faced should not be considered *content* gaps as much as *context* gaps as they move from one



activity system to another. Similar to the experience gaps Leydens' 2008 study [27] noted, the participants experienced major contextual differences surrounding communication activities. Although their communication experiences within capstone projects produced structural knowledge of genres and the role of communication within engineering tasks, the local circumstances of their professional environments were not fully replicated. Due to the embedded nature of communication practices in the workplace and the way that they shape new engineers' communication activities, there are pieces of communication instruction that school simply cannot replicate. The contextual shift required as new engineers move from school to work will always involve a gap. Although closing this gap completely is unrealistic, the following suggestions are intended to help recognize it for what it is (a *context gap*) and provide ways to help narrow this gap more quickly.

**Recommendations for Capstone and Communication Educators** To address the *context gap*, capstone and communications educators should consider ways to adapt their courses to provide an atmosphere that aligns with industry more closely than traditional academia and moves students toward the workplace realities advocated by Dias et al. [5]. Although impossible to completely replicate workplace activity systems, capstone courses could effectively introduce students to workplace expectations and communication activities, and coach them through these interactions.

To help students develop meta skills, communication educators should be more explicit that the common engineering genres emphasized in the classroom will be embedded in context-dependent activity systems in the workplace. That is, consistent with rhetorical genre theory, instructors can help students understand not only the structure of the genre, but also the recurrent social situation to which it responds, and the ways in which the structure and the social exigence are connected. Although these new activity systems may have some similarities to academic settings, instructors can explicitly communicate to students that the workplace will be very different in many ways and that there is no way to replicate all of its particularities.

To expose students to members of a particular workplace's activity system, capstone educators can solicit participation from industry representatives in the capstone course. Industry

participation can range from a guest appearance to full integration within the capstone course; the deeper the involvement, the greater the cross-cultural learning opportunity for the students. Capstone projects that are initiated, defined, and guided by industry engineers provide students access to environments outside of the typical educational setting. As another less intensive example, inviting industry engineers to evaluate capstone presentations as judges or reviewers provides an opportunity for students to experience the kinds of presentation reviews that await them in engineering workplaces and exposes students to the types of questions asked by engineers who are not their teachers.

In addition, given the kinds of challenges that participants experienced, capstone and communication educators should think beyond the typical genres required from engineering design projects (proposals, presentations, reports) and ensure that other communication activities such as informal and interpersonal communication exchanges with colleagues, superiors, and external customers are also emphasized. In the workplace, interpersonal interactions occur at multiple levels up and down the chains of command. Capstone courses can provide similar opportunities for students to participate in those informal communication activities both within their project teams and when communicating to superiors.

As highlighted in Wisniewski's case study [33], novice engineers often participate in communication-related project-management activities including project planning, meeting coordination and facilitation, and documentation and follow-up [33]. Capstone teams rely on these same activities to successfully complete projects. Instructors can highlight the significance of communication within these tasks, calling students' attention toward effective ways of asking questions, sharing progress, and seeking clarity through interactions with peers and superiors.

Finally, the importance of explaining to students that every company is different and has its own sociocultural environments cannot be overstated. Students should be reminded that flexibility is important and that they need to be prepared to adapt to a new system with its own set of tools, actors, and customs.

**Recommendations for Industry** Although capstone courses can provide students with effective guidance in a range of communication

practices, new engineers will always experience a learning curve based on the context gap described in this article. Companies must expect new engineers to enter their workplaces without experience performing all activities associated with their jobs, including all the different communication activities. New employees still need to learn the individualized norms and expectations of their new workplace. As previously stated, the classroom cannot replicate all the nuances and factors involved in communicating within a particular organizational environment. Companies hiring engineering graduates can share a role in helping new employees successfully transition to the workplace environment, especially if the onboarding process encourages new engineers to draw upon prior educational preparation, particularly capstone experiences.

Organizations with programs designed to ease the transition and shorten the learning curve could help support new employees. Although this task is often assigned to a human resources department, it is more appropriate for hiring managers to assume this responsibility. Managers can help new employees better understand the organization's communication culture by overviewing the department's preferred communication style, including examples of the most common types of communication. The more difficult-to-learn hierarchy of whom to ask what questions could also be addressed by a hiring manager or mentor. More experienced employees have likely already learned this hierarchy and could share it with new hires rather than expect them to learn it themselves the hard and more frustrating way.

Complicating these suggestions is that their success depends highly on individual employees effectively helping the new engineer. Thus, choosing the right current employee to guide and mentor the new engineer is a critical component in closing the context gap.

### Limitations and Implications for Future Research

Although this study included a large sample size and multiple data-collection methods

to provide a rich set of insights, it was not without limitations. The participants were former students of some of the researchers, a factor that could have bearing on the interpretation of findings. However, measures were taken to reduce such bias, including using numbers (versus names) for participant data collection and analysis and distributing main coding tasks to graduate student researchers. Because the participants were from three mechanical engineering programs and one engineering science program, findings might not be transferable across all engineering disciplines. The participants were self-selecting, introducing the possibility of an inherent bias from participants who considered themselves more prepared for work. In addition, new engineers' participation in the study may have changed the way that their reflection and strategies were employed, impacting their approaches to work. Finally, not all participants completed every survey or interview, resulting in some gaps in the reporting.

As this study was limited to findings based on new engineers' self-perceptions, it does not include information clarifying how the participants' performance on communication tasks was viewed by their colleagues or superiors. Studies designed to include those perspectives would allow for a better understanding of how coworkers participate in the new engineers' enculturation process. Future research could more deeply investigate the relationship between new engineers' rhetorical awareness and their understanding of particular workplace contexts. Examining the role of communication activities more closely within various stages of engineering could broaden our understanding of which engineering activities might require more rhetorical awareness and context familiarity than others.

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