

Interns in the Wild: Using Structured Reflection and Interviews to Investigate Early Career Engineering Practice

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Introduction

A growing body of research on engineering practice suggests that engineers are often expected to coordinate, collaborate, and communicate across diverse boundaries, including organizational, disciplinary, demographic, stakeholder, cultural, temporal, and spatial, to name a few. For example, research by Lynn and Salzman led them to conclude that engineers urgently need “cross-boundary skills” to enable working “across disciplinary, organizational, cultural, and time/distance boundaries” (p. 82).¹ Hanneman & Gardner more generally identified boundary spanning skills and competencies as increasingly important for college graduates, including engineers.²⁻³ And in his studies of professional work in software and R&D units in global firms, Johri found that engineers and other technical professionals are frequently expected to assume key roles as “boundary spanning knowledge brokers.”⁴

To shed further light on the boundary spanning realities of engineering practice, the authors are leading a larger research project focused on two main questions: 1) What specific boundary spanning roles, activities, and competencies are most important and prevalent for early career engineers, and 2) How do early career engineers experience boundary spanning challenges? To address these questions, the research team first performed a qualitative systematic literature review to develop a more holistic understanding of how the phenomenon of boundary spanning is understood in the extant literature. These findings also informed the creation of a codebook that is now being used to analyze more than 20 interviews conducted with early career engineers working as interns or full-time employees in various manufacturing firms.

As the research team started to see novel insights emerge from the interview data, they also wondered how they could get even closer to the experiences of the engineers. For example, spending time on-site as a participant observer or performing an in-depth job task analysis could produce novel insights about the subjects and their work. However, these approaches come with new challenges, including as related to research costs and timelines, gaining access to research sites and subjects, and adapting to the use of new research methods and skill sets. In light of these issues, this paper describes how we used structured reflection activities and post-experience interviews as an alternate way of making visible the realities of engineering practice.

More specifically, we report on data collected from two engineering students in semester-long internship appointments in large manufacturing companies. Each of these students completed three reflection activities during their internship experience: the first after a few weeks in their positions, the second after about six weeks, and the third and final during their last week of work or shortly thereafter. Each wave of data collection involved a partially distinct set of reflection prompts, developed based on the primary phenomenon of interest (i.e., boundary spanning), their internship timeline, and insights gleaned from previous rounds of reflection.

In this paper, we aim to clarify the methodological considerations and approaches we employed. In particular, we are interested in exploring how our specific data collection approach, namely collecting reflections combined with a follow-up semi-structured interview, impacted the quality

and trustworthiness of the data. With this broader theme in mind, two more specific objectives are the primary foci of this paper:

- Objective 1: What do the reflection data and follow-up interviews make visible about engineering practice, including in terms of boundary spanning?
- Objective 2: How do participants respond differently in the reflections and interviews, and how is this potentially related to personality or other individual characteristics?

In support of these objectives we first consider the challenges of studying engineering practice and how others have conducted such research. Second, we report on the types of reflection prompts we developed, justification for their use, and what we hoped they would reveal about the lived working experiences of engineering interns. Third, we consider what the reflections made visible (and not), including a high-level overview of findings related to boundary spanning and other emergent themes. Fourth, we describe differences observed in comparing the two participants' responses to one another, and also in comparing the reflection and interview data. We conclude by discussing implications and directions for future research, including further data analysis efforts and plans for integrating the reflection and interview data. We expect that this paper will primarily appeal to engineering education researchers seeking innovative methods for studying practice in the engineering workplace and/or other contexts (e.g., teaching practice). It may also be relevant to those interested in using reflection to scaffold experiential learning.

Background and Literature Review

In their contribution to the *Cambridge Handbook of Engineering Education Research*, Stevens et al. note a puzzling “sparseness of research on professional engineering work” (p. 119).⁵ Nonetheless, their review chapter provides a useful survey of related empirical investigations. They more specifically point to “field studies” as a prevalent approach, with typical data sources including fieldnotes, video recordings of work practices, and semi-structured interviews. Indeed, in our own attempts to identify relevant literature we have similarly found interview data as a prevalent source of evidence used to characterize engineering practice, including in studies focused on the experiences of early career engineers. Representative examples include: Korte's study of organizational socialization among early career engineers based on interviews with newly hired engineers and select managers⁶; research by Brunhaver et al. on gaps between engineering education and practice based on interviews with engineering students and newly hired engineers⁷; and research by Trevelyan and Tilli that aimed to identify the specific kinds of work activities performed by recent engineering graduates in Australia.⁸

Yet commentators have noted some of the limitations associated with interview data. Stevens et al., for instance, point out that ‘interviews are less than fully sensitive to the broad range of knowledge practices, especially its tacit dimensions ... which are largely inaccessible to reflective awareness’ (p. 126).⁵ They additionally point to ethnographic studies as better suited to capturing the “embodied, material, and distributed qualities” (p. 126) of engineering practice.⁵ Stevens and Vinson have also pointed to benefits associated with direct observation over interviewing, including to “learn the native language” of diverse research subjects in a wide variety of job roles and situated in different organizational settings.⁹ Buch similarly notes the

prevalence and utility of ethnographic and “grounded” approaches for investigating engineering practices “as they unfold in natural settings” (p. 129).¹⁰ He also describes more specific types of ethnographic studies in the extant literature, such as those focused on day-to-day work practices, the broader life-worlds/stories of engineers, and the formative process of becoming an engineer.

Nonetheless, there are a variety of challenges associated with carrying out in-depth ethnographic studies. Stevens and Vinson mainly raise practical concerns, describing the difficulties they have faced in trying to carry out in-depth ethnographic studies of early career engineering practice.⁹ Most notably, they have been repeatedly stymied by corporate gatekeepers in their efforts to gain access to research subjects and sites in the first place. In response, they propose some strategies for better conveying the potential value proposition of such research to prospective partner firms. Buch’s concerns are mainly theoretical and methodological.¹⁰ He more specifically argues that many ethnographic studies of engineering practice fail to adequately consider or acknowledge the deeper ontological and epistemological presumptions that undergird the research. Buch in turn calls advocates “methodological pluralism” or a “toolkit approach” in studies of practice.¹⁰

To be sure, some studies of engineering practice have leveraged other types of empirical evidence. For instance, studies by Trevelyan and Tilli, Trevelyan, and Williams and Figueirido coupled interview data with results from online surveys that asked engineers to report how much time they committed to certain kinds of work tasks in a typical week.^{8, 11-12} Our initial reliance on interview data similarly led us to ponder how we might glimpse early career engineering practice through other data sources, including by using approaches that could bring us closer to situated practice while also enhancing our ability to collect data more periodically over time. We also wanted to avoid any new difficulties associated with gaining access to research sites or greatly expanding the scope of our data collection efforts. This led us to recognize reflection as a promising source of research data that might prove relevant and complimentary to our study goals. We were in part inspired by a more general “upward trend” of reflection in engineering education,¹³ as well as our own prior experiences collecting and analyzing such data.

The engineering education literature has mainly focused on the use of reflection activities to support learning and assessment in formal education settings (e.g., in traditional coursework). However, there are a few examples of reflection being used to scaffold experiential learning. For instance, Clarkson University requires students to respond to a series of reflective prompts after completing a professional experience requirement (e.g., internship or co-op, research experience, honors thesis, service learning, etc.).¹⁴ Similarly, our team has been involved in efforts to use reflection to support student learning and program assessment in the context of international research experiences for undergraduate and graduate students and in global service learning projects.¹⁵⁻¹⁷ However, we are not aware of any other projects which have used reflection data as a source of empirical evidence for characterizing engineering practice.

Methods

Participant recruitment

We worked with our university’s co-op office to recruit students who were in co-op/internship positions during the Spring 2016 semester. Since we were looking for participants who would be

involved with our reflection activities throughout their co-op experiences, we first created a screening survey to make sure we had participants who met our criteria and who were dedicated to completing all reflection activities and a follow-up interview. We also informed participants that they would receive a \$50 gift card upon completion of all study procedures.

The screening survey included questions about the industry sector in which the students were working, company size, start and end dates for their position, and job title. Eight people responded to our screening survey, seven qualified for participation, and six completed all reflection activities and the follow-up interview. Our inclusion criteria required that participants had completed at least one internship/co-op rotation prior to their current position, that they were employed in a manufacturing or electronics industry setting, and were seeking degrees in mechanical, electrical, or industrial engineering. Additionally, we were looking for an ethnically diverse group that included a representative sample of women.

Characterization of participants

Since this paper is mainly focused on a discussion of methods, the research team selected two participants on which to focus their efforts. These two participants were selected because they had similar demographic characteristics, thereby allowing us to more easily compare how they responded to the reflection activities and in the interviews. This helps control for some potential differences in ways of responding that might be linked to other factors, e.g., gender or discipline.

Both participants we will discuss in the remaining portions of the paper were female electrical or computer engineering majors at a large, public Midwestern doctoral university with very high research activity. One participant identified as White/Caucasian and the other identified as Hispanic/Latino. One had spent more than ten years living abroad and the other had never lived abroad. Both were employed in manufacturing environments at companies with more than 3,000 employees, and were working as co-op employees from January through May of 2016

Data collection

All data collection for this study was carried out under appropriate protocols and approvals for research involving human subjects. The three reflection activities used to collect data for this study were developed sequentially, and each participant was provided their previous responses when they were asked to complete the second and third reflection activities. Each of these students completed three reflection activities during their internship experience: the first after a few weeks in their positions, the second after about six weeks, and the third and final during their last week of work or shortly thereafter. The three reflection activities were comprised of prompts focused on three thematic areas of interest: describing the internship experience, describing working relationships, and reflecting on specific work scenarios. We also explored aspects of the participants' personalities in the third reflection. The reflection activities were administered online through the Qualtrics survey platform. Table 1 gives an overview of the reflection prompts organized by area/theme.

Table 1. Overview of reflection prompts and themes

	Reflection Activity #1	Reflection Activity #2	Reflection Activity #3
Describe Internship	What are you most looking forward to, and what do you hope to learn, during your current internship/co-op appointment?	How is your internship/co-op experience aligning with your expectations so far?	To what extent have your expectations for this internship/co-op been exceeded, been met, and/or not been met?
		What tasks and activities do you MOST look forward to on a daily basis? What tasks and activities do you find LEAST desirable?	
		What are your goals for the remainder of your internship?	
Describe Relationships	Tell us about a typical workday as you experience it on an hour-to-hour basis.	As compared to your response from R1, how has your typical workday changed (if at all)?	What notable changes (if any) have occurred in your workday, responsibilities, attitudes, and/or coworker interactions since your previous reflection?
		Who do you find most enjoyable to work with and why? Who do you find most challenging or difficult to work with and why?	
		How would you describe your co-workers' impression of you?	
Situation Reflection	Tell us about one specific example of a work situation where you encountered and spanned boundaries. What was the outcome? How do you feel about how this situation unfolded (or is unfolding)?	Reflect on a situation you described in R1 if it has remained unresolved, or focus on a new situation that you are currently experiencing.	Identify one POSITIVE/NEGATIVE experience that you would be most likely to use in a future job interview to demonstrate what you have learned and how you developed in this internship.
Personality			What aspects of your personality have you identified as strengths/weaknesses in your internship/co-op position?

The second reflection activity built directly upon the first. After reviewing the responses for the first reflection activity, the research team decided to ask participants to review their first reflection activity responses. They were then asked to describe any changes in their co-op role or experiences, describe their work relationships, and finally to revisit the boundary spanning scenario they described in the first reflection activity and share any relevant updates or new developments. Participants were also given the option to share and describe a new situation.

The third and final reflection activity again asked the participants to review their responses to reflection activities one and two, and then to take a brief thirty item personality inventory.¹⁸ For each personality trait the participants rated themselves on a five-point scale with anchoring adjectives at both extremes, an example of which is shown below in Figure 1. The thirty traits included in the inventory are grouped into five main personality dimensions: neuroticism vs. emotional stability, extraversion vs. introversion, openness vs. closedness to one's own experience, agreeableness vs. antagonism, and conscientiousness vs. undependability. Each dimension is comprised of six more specific items, allowing for a total score for each dimension to range between 6 and 30, with 18 representing a neutral or midpoint value across six items.

Neuroticism versus Emotional Stability:

5 4 3 2 1

1. **Anxiousness** (fearful, apprehensive) ○ ○ ○ ○ ○ (relaxed, unconcerned, cool)

Figure 1: Example personality inventory item as it appeared to participants¹⁸

The participants were then prompted to reflect on their personality strengths and weaknesses via the prompts indicated above. They were next asked to give another update on the status of their co-op experience, and finally they were presented with an option to reflect on a specific scenario or situation from their internship experience, this time using the STAR method. The STAR (Situation, Task, Action, Result) method is used for professional interview preparation by the career center at our university.¹⁹ Since all co-op students are required to submit a final report on their work experience to the university's co-op office, this optional task was potentially beneficial to them even beyond the scope of the study.

In addition to the reflection activities, each participant completed a follow-up interview with a member of our research team. The follow-up interviews took place after the co-op/internship experiences were complete and were conducted in person. The purpose of the follow-up interview was to gain additional insight into the experiences of the participants. The interview protocol was semi-structured and relied heavily on the reflections themselves. For example, the interviewers started by again asking participants to describe a typical day in their co-ops/internships. Since we wanted to be able to compare the data from the reflections to the interviews, asking similar questions helped us see if one approach may elicit more detail and depth than another. In addition to asking the participants to describe their co-ops/internships, we asked the participants to describe their workplace relationships, their biggest challenges and successes, and how they think their personality might help or hinder them. We also asked follow-up questions about select boundary spanning experiences drawn from their reflections.

Data analysis

Each participant's data was originally compiled in four documents, three for the reflection activity responses and one for the transcribed interview, resulting in eight total documents for

two participants. Before proceeding with data analysis, the transcripts were cleaned to remove any details that might allow identification of the subjects. Each of the documents was uploaded into a project file in NVivo and three co-authors each coded all documents individually using a codebook that had been developed to analyze interviews conducted with early career engineers during an earlier phase of data analysis. An overview of this data analysis process, as well as some preliminary results, are presented in previous conference papers.²⁰⁻²¹ The same three co-authors met to resolve any disagreements and to finalize the codes. Next, all of the researchers met to discuss the most prominent themes with respect to the goals of this paper, namely, which examples best demonstrate what our methodological approach made visible about practice? In writing up the results, pseudonyms were assigned to conveniently distinguish the two subjects.

Once all the reflection and interview data were coded, we used frequency counts to compare the quality of the data for both participants. We also scored the personality inventory from the third reflection activity following a typical approach to analyzing the data from such an instrument. While this paper is mainly focused on questions of methods and methodology, we include extensive quotations directly from our data. This allows us to be more transparent in exploring the quality and trustworthiness of the data while enabling readers to draw their own conclusions.

Findings

We organize our findings by objective and begin with a quantitative overview of what the reflection and interview data made visible. We then provide qualitative evidence to compare responses from the two participants, and also to compare the reflection and interview data.

Objective 1: What do the reflection prompts and follow-up interviews make visible about engineering practice, including in terms of boundary spanning?

With three reflection activities and one semi-structured interview of approximately one hour in duration for each participant as the basis of our data analysis, we were curious to see how much of our data analysis codebook would be covered. The basic structure of our codebook focused on seven coding categories or nodes, some of which have multiple sub-nodes, as shown in Table 2.

Table 2: Overview of coding categories and nodes

Codebook category or node	Description of category or node	Nodes
Activities – Boundary spanning	Participant describes a boundary spanning activity performed by the participant and/or demonstrates awareness of boundary spanning activities	5
Activities – Technical	Work activities that involve technical expertise or tasks (e.g., calculations, analysis or modeling, design, CAD drawings, etc.)	1
Boundary Types	Participant shows awareness of boundaries in their workplace and/or describe a situation in which the participant crossed one or more boundaries	9
Emotion	Affective/emotional aspects of boundary spanning activity (e.g., frustration, anger, satisfaction, etc.)	1
Learning	Explicit evidence of learning that occurs in the	1

	context of boundary spanning activities or work tasks; realizations about work/life balance	
Job Roles	Participant describes his/her job role	1
Competencies and Attributes	Participant demonstrates explicit awareness of competencies, attributes, capabilities, and/or strategies as they relate to boundary spanning	1
TOTAL		19

Table 3 gives an overview of all data sources and coding counts for both participants, Mary and Sophia. We see that much of our codebook was covered, particularly through the semi-structured interviews. As indicated, Sophia was the more verbose respondent, with the total word count for her reflections and interviews more than triple Mary's total word count. Additionally, the total number of coding instances for Sophia's data set was about double that of Mary's. Based on these metrics alone, one might infer that Sophia's data was much richer, offering more evidence with greater detail. While the examples presented below show that this was to some extent the case, it is worth noting that overall coverage of the codebook (i.e., in terms of total number of different nodes used in the coding process) was roughly comparable for these two subjects.

Table 3: A comparison of word, node, and coding counts for our two participants

Participant:	Mary			Sophia		
Data source	Word count	No. of nodes used (of 19)	No. of coded instances	Word count	No. of nodes used (of 19)	No. of coded instances
R1	667	13	29	1084	13	29
R2	252	12	22	2310	17	67
R3	409	10	17	1034	10	21
Interview	3,255	19	118	9,945	18	242
Totals	4,583	N/A	186	14,373	N/A	360

Since Table 3 only gives an overview of number of coded instances, we also wanted to see how Mary and Sophia's data compared in terms of more specific coding patterns. Table 4 therefore presents coding counts for each subject further broken down by reflections versus interviews and by each major codebook category or node. Since Boundary Types has 9 sub-nodes, it makes sense that it was coded most often across both the reflections and interviews. It also makes sense that there were more total coded instances in the interviews than in the reflections for both of the participants, since the interviews lasted relatively longer than the reflections, and an interviewer has opportunities to follow-up and probe on particular points. However, for some codes, such as Learning, we see that the reflection activities actually elicited more coded instances than the interviews. In other instances, such as Technical Activities, we find that Mary's data had more coded instances in her reflection data, while Sophia had more coded instances in her interview.

Again, it is encouraging to see that the breadth of our codebook was covered by the data collected from both participants, potentially demonstrating that boundary spanning is a useful lens for examining early career engineering practice. Yet this numeric evidence does not really distinguish the reflections versus the interviews in terms of making visible how students in co-

op/intern positions actually experience engineering practice. Our second objective requires a closer and more qualitative comparison of the data collected from these two research subjects.

Table 4: Coding counts by subject, data source, and coding category

Participant:	Mary		Sophia	
Codebook category or node	Reflections	Interview	Reflections	Interview
Activities - Boundary spanning	8	24	15	29
Activities – Technical	6	4	2	14
Boundary types	31	62	54	160
Emotion	5	4	3	15
Learning	9	6	17	5
Job roles	4	4	11	7
Competencies and attributes	5	14	15	11
Totals	68	118	117	242

Objective 2: How do participants respond differently in the reflections and interviews, and how is this potentially related to personality or and/other characteristics?

While the objective of getting the participants to write about boundary spanning experiences through structured reflection activities did seem to be effective for both the participants, the way they responded to specific reflection questions often differed substantially. For example, in Figure 2, we contrast how they replied to a question asking them to describe a typical workday.

Tell us about a typical workday as you experience it on an hour-to-hour basis. In your description, please identify persons with whom you interact frequently (including their job titles, affiliations, relationships to you, etc.), as well as the major projects and tasks you are working on.	
Mary's response	I always talk and ask questions with [Ali], who is a design lead that reports to the same supervisor that I have been assigned to, regarding my projects and progress. He and my supervisor (who is a direct responsible) assigned me my projects for this rotation. One of my projects involve a bus networking device that I am currently learning from a supplier who comes in every morning to teach me.
Sophia's response	Usually, I will arrive to work around 6.10am, walk through the turnstile to Plant 1, and arrive to the [hosting] department around 6.20am. This is the time to check on what might have happened at the plant during shifts B, and C (I work shift A) since the plant runs 24 hours a day. I'll check my emails, calls and messages from the day before and around 6.30am pick up reports from the printers. The reports simply show what errors cars have had during the last 24 hours at different parts of the line. I'll walk to plant 2 and put up some of the reports on a white board on the line, and return to my desk in plant 1 to attend a department meeting at 7.00am. After the department meeting, I'll work on my projects until around 11.00am. The [hosting] department is in charge of the electrical aspects of the car: wiring, control units, sensors, programming, testing, etc. Therefore, I can ask [Jessica] (in charge of making sure the line runs smoothly from the connector side, as well as interacting

	with the line workers to smooth processes), Daniel (my ... supervisor), [Victoria] (in charge of hybrid cars), [Stan] (in charge of the engine/camera testing of the car) or [Kevin] (one of the programmers in our team) for any projects they might have for me. My projects include writing code that can extract small amounts of data to simplify certain tasks for the programmers, inventory connectors in plant 2, running tests on cars, or work on some of the other projects I've worked on during past rotations (one of which being a black box that tests if a diode is in working condition). Our team has to deal with troubleshooting and finding the causes of errors, so my projects are short-term and varied. Most of my day usually consists on me trying to learn more about the processes the cars go through and how I might offer support for any of the other members on our team. At 11.00am, I will go to lunch and return around 11.45am to continue working on projects until the end of the work day at 3.00pm.
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Figure 2: Comparison of Mary and Sophia's responses to the same reflection question.

As this comparison makes clear, Mary's response is much shorter than Sophia's. In terms of coding density, Mary's segment has six codes associated with her response as compared to eight total codes for Sophia's. While this might seem like a minor difference, Sophia's account is very detailed and nuanced, with thoughtful descriptions of technical work tasks, and specific references to many coworkers, including brief sketches of their job roles and responsibilities. As a representation of engineering practice, Sophia's data is considerably richer and more valuable.

The differences in responses might be attributed to a variety of factors, including: how much time the subjects dedicated to the task, how they interpreted (or misinterpreted) the reflection prompt, what other work or non-work pressures they were facing at the time, and even more generally how committed they were to completing the study requirements. As we note below, personality and other individual characteristics might be another explanatory consideration.

Yet even when considering each participant individually, we find that certain questions or topics elicited very different responses in reflections versus the follow-up interview. For example, Sophia describes one specific co-worker in both a reflection response and later in her interview. The descriptions vary notably, as presented in Figure 3.

Reflection	[Theo] is German, and by spending time with him I realized working with him isn't the most pleasant experience and he values when people speak his language. He is really blunt and sometimes even comes off as rude.
Interview	He's [Theo's] very serious and he's very straight and he's very detailed. He's by far the most difficult character in that department.

Figure 3: Comparison between Sophia's responses in her reflection and interview

Sophia's chooses rather different words to describe her experience working with a co-worker in the reflection and interview. The reflection statement is more candid and expressive, while the language in the interview is more reserved and diplomatic. There may be a number of reasons for this difference, including the fact that the reflection was a more near-experience rather than retrospective account. Further, Sophia might have felt the need to be more professional or tactful

in the context of a face-to-face interview. Yet the two statements are largely complimentary and consistent, arguably providing us with an overall richer view of Sophia's experience.

While the reflection might be able to provide candid, real-time reactions to specific workplace experiences, interviews also allow for the interviewer to probe more about an experience and elicit additional details, especially if the participant's description is incomplete or unclear. Reflections are rigid, and if a given participant does not think or want to elaborate in response to a given prompt, s/he does not need to. In light of such limitations, the example presented in Figure 4 shows the reflection activity and interview being used in tandem to build a more comprehensive understanding of one of Mary's boundary spanning work situations.

Reflection	<p>As being part of the validation team, I was to test and evaluate different modules in a certain sequence on many different types of modules. I was to report everything in a document that the persons in charge of the modules can talk with me and see the report as well as my supervisor whom I report directly to. If an issue arises I have to contact the different groups that can change the software, debug the module messages, and the group that can rebuild the networking modules. There are a lot of people involved with each module.</p> <p>So when the issue of a faulty message not getting through to the other networking modules arose, I followed the issue with the engineers of the different groups, asking questions, and making sure that they understand that there is a deadline and I needed the module fixed.</p>
Interview	<p>Interviewer: I remember from your reflection, you mentioned a situation where you had given the deadline and you were working on that, creating some sort of deadline, you were working on that. You mentioned the next time when you get that kind of deadline and you need to complete some tasks, you would prefer to get more people on board. Do you remember that situation?</p> <p>Mary: I don't remember it.</p> <p>Interviewer: Do you want to go through it? This one.</p> <p>Mary: Oh, this one, okay. This one was ... There were not many people on board with it, it was me and two other co-workers.</p> <p>Interviewer: So this task was given to you, to work on that, the deadline is coming and you have to talk to different people, right?</p> <p>Mary: Right. Basically, if you've ever heard about the issue with the hacking incident, the vehicles, this was related to it. This module was supposed to keep all the hacking signals away, and all the valid signals go through. It was fairly new and I was validating it, it was all these issues, so I had to talk with suppliers about these issues. There weren't enough people working on it in order for those supplier to say "Hey, can you give me this new module? Let's test it." It was very slow going because there were only a couple of people.</p> <p><i>[line of questioning continues]</i></p>

Figure 4: Comparison of Mary's responses in reflection response and interview

Mary's reflection data as presented in Figure 4 had seven coding instances, each representing a different node, thereby suggesting that this is a potentially rich incident for this study. Yet

similar to the example given in Figure 2, Mary's initial written description of this situation is rather sparse on details, clocking in at only 145 words. Recognizing this fact, this same situation was again discussed in our follow-up interview with Mary. It is worth noting that Mary initially reports not remembering this incident, which suggests that this particular example might not have surfaced in the interview were it not for the earlier collection reflection data and intentional use of that data by the interviewer. Yet once she recalls this specific example, the line of questioning shown above continues at considerable length to reveal the nuance of this incident, especially in terms of specific boundary types and boundary spanning activities. In fact, the portion of the interview discussing this one incident is comprised of nearly 800 transcribed words, and more importantly had a total of 18 coded instances across 13 different nodes. As this example suggests, interview data can be considerably richer than reflection data since it can allow the researcher to probe for additional details. Yet the two data sources used in tandem appear even more powerful, as it allows the researcher to revisit, validate, and probe around specific examples to develop a much "thicker" description of the phenomenon under investigation (i.e., early career engineering practice in general, and boundary spanning in engineering more specifically).

One might additionally wonder whether the process of completing a reflection response could provide details that the participants would not remember or would not like to share in the follow-up interviews. As a contrasting example, Mary experienced incidents of sexism in the workplace, and describes this in a reflection response with considerable detail. Yet when she is asked about this experience in the interview, Mary seems to hesitate to elaborate, as shown in Figure 5.

Reflection	I have been repeatedly experiencing sexism in the workplace this whole rotation. I was given the task from my supervisor to work on a project with a coworker that didn't like women that had to work with him. He gave me the job of looking through all these word documents and creating an excel spreadsheet from them. How I worked around the dislike from him, was not asking him any questions and figuring out the scope of the project myself. In the end, I handed him the excel sheet before the deadline and he thanked me. I did not get anymore dislike from him, but he is still not that open towards me. The main thing is that I got the job done without creating tension.
Interview	<p>Interviewer: I have one more reading here, when I was reading through your reflection prompts and you said about the gender bias, having the sexist nature of your design lead, you said they were surprised when you had something to do.</p> <p>Mary: Yes. They were surprised, with the exterior lighting, they were surprised I was actually working on that.</p> <p>Interviewer: Can you talk about that situation a little bit more?</p> <p>Mary: There was like, "How is this one project going along?" I'm like, "It's okay, but I'm working on this one, with this person." They're like "Oh, you actually are working on this?" I'm like, "Yeah, I am."</p> <p>Interviewer: He didn't have any problem with that?</p> <p>Mary: He didn't. He was actually pretty happy that I was finding something.</p>

Figure 5: Comparison of Mary's responses in reflection response and interview

Here we observe two different perspectives from Mary on working with a difficult – and likely sexist – colleague. The nearness to experience associated with the reflection activity may help explain why the written description of the incident is clearer and more candid than the interview. It may also be the case that Mary was simply more comfortable writing rather than talking about this particular issue. In fact, it is not fully clear whether Mary’s remarks in the interview are referring to the same situation or person. In this instance, we suspect the reflection data is more trustworthy and useful in terms of characterizing this particular on-the-job experience.

As mentioned above, personality differences might also help us understand variations in how each subject responded to the reflection prompts and interview questions. When analyzing the personality inventory data, the research team saw in general a fair degree of similarity for both participants across the five dimensions, as shown in Figure 6. Most notably, both Mary and Sophia reported being highly conscientious. Each also displayed extraversion over introversion, agreeableness more than antagonism, and emotional stability rather than neuroticism, albeit to varying degrees. Only in the category of openness did the participants fall on opposing sides of the spectrum, with Mary appearing more closed to experiences and Sophia relatively more open.

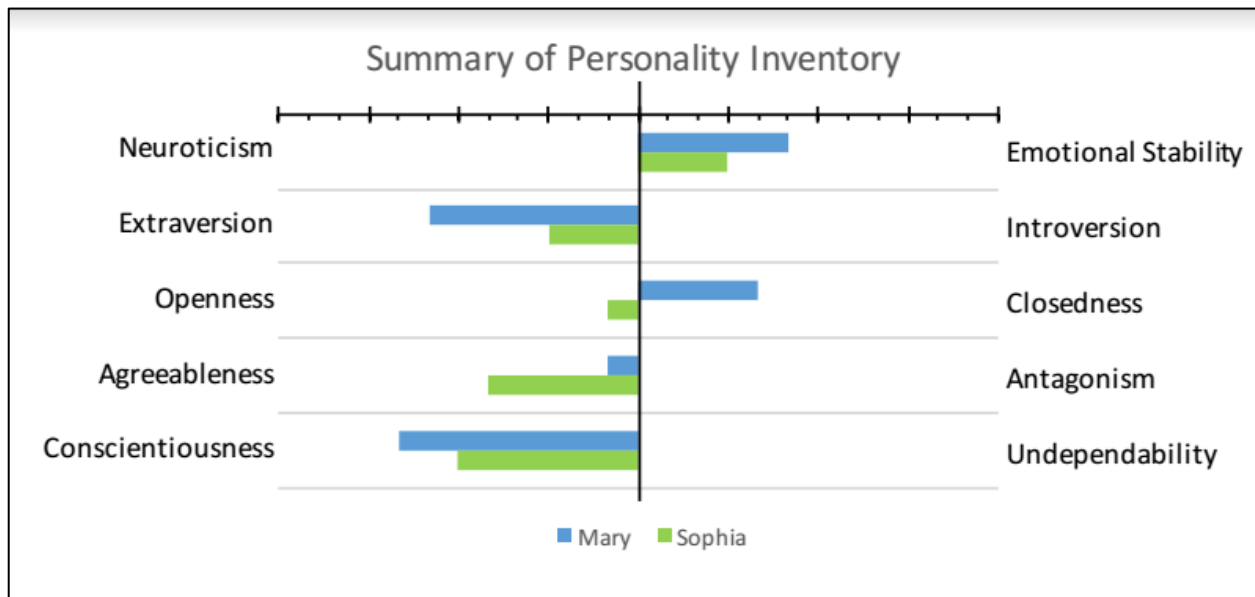


Figure 6: Summary of personality inventory results

At the individual item level, the research team was most interested in how the personality inventory findings relate to the participants’ self-described strengths and weaknesses, which appear below in Figure 7. Mary’s responses about her perceived strengths are consistent with her high scores in all Conscientiousness items, notably Dutifulness and Achievement, and her “outgoing behavior” aligns with an extremely high response to Gregariousness. Interestingly she identifies her assertiveness, scored high in the inventory, as a weakness in her co-op position where she has been, “too quiet for [her] liking” in contrast to her natural extraversion. Sophia presents a similar pattern in that her identified strengths and weaknesses are consistent with her inventory data for traits within extraversion, agreeableness, and conscientiousness. She also demonstrates self-awareness that there is a great deal of overlap between strength and weakness, depending upon the situation and surrounding individuals.

	What aspects of your personality have you identified as strengths in your internship/co-op position?	What aspects of your personality have you identified as weaknesses in your internship/co-op position?
Mary	My determination and outgoing behavior. I always wanted to keep busy and will make sure that I have something to do.	My assertiveness. I have been too quiet for my liking because I have been shot down so many times here.
Sophia	My latest co-op rotation has helped me realize I am the type of person that people can go to when they need to talk and not be judged. I'm a talker, in the sense that I need people to share a conversation with, but I am also relatable--I very rarely will find myself telling someone I don't understand their situation/can put myself in their shoes. This has proven to be useful in the workplace, because I can easily relate with coworkers and when I need help I can find coworkers who are more willing to help me out, as well as relating with people in other departments. I've also realized that I have very high standards for my work ethic. I can tell when it is okay to joke with coworkers, but when the job needs to be done, I am reliable. In my work scorecard, my manager also stated that he appreciated my go-getter attitude. I must admit, this is a new trait that I find has really helped me during this rotation.	I also realized that my willingness to do work also results in my getting involved in situations that might be a bit out of my comfort zone. I also realized that sometimes the outgoing side of my personality might cause some people (those who are a little more reserved) might feel uncomfortable with my presence.

Figure 7: Participants' self-described personality strengths and weaknesses

Discussion and Conclusion

Regarding the first objective of this paper, we observe that the reflection and interview data seem to provide ample insights regarding early career engineering practice, particularly in terms of the primary phenomenon of interest (i.e., boundary spanning). This is reflected in both the breadth and depth of coding across our codebook. Yet closer examination of the total word and coding counts suggests that one of our subjects provided us with richer and potentially more useful data, even though both participants had similar demographic characteristics and completed the same study protocol (three reflection activities and one follow-up interview). Nonetheless, it is notable that even the more taciturn of the subjects provided us with data saturating our entire codebook.

In support of our second objective, we turned to a more qualitative examination of the data collected from the two research subjects. At least four main points are worth summarizing. First, the examples presented above help demonstrate how Sophia's responses typically provided us with a much "thicker" description as compared to Mary's. Second, we observe that reflection activities may be preferable for capturing near-experience data, particularly from subjects who enjoy writing or journaling about their experiences. These advantages might be especially pronounced when individuals are grappling with difficult or uncomfortable situations and are more willing and able to express their emotions in writing. The reflection activities also have a practical advantage, as they provide greater flexibility for the subjects and researchers. Third, the interviews have an advantage for eliciting detail from recalcitrant subjects, including through the use of follow-up questions and probes. Some subjects may also be more willing to discuss difficult situations in an interview setting if sufficient rapport is established. Fourth and most importantly, we propose that reflections and interviews are very compelling when used together. Together, they allow the researcher to better establish the quality and trustworthiness of the data, including by triangulating evidence from multiple sources. Their use in tandem can also help reveal how a given subject's perspective changes over a given period of time, while providing multiple opportunities to revisit and clarify details to build an overall thicker description.

The personality components of the reflections and interviews raise many additional points of discussion. In terms of selecting research subjects and collecting data, we might even propose some tentative insights regarding what constitutes a "good" participant. It is notable that both of the students examined in this paper scored high on conscientiousness, agreeableness, emotional stability, and extroversion. All of these personality traits may be preferable when conducting a study such as ours, since these traits suggest that a given subject will respond thoughtfully to a set of reflection prompts and in an interview. For example, someone who is agreeable might be more cooperative and trusting when interacting with the research team, and someone who is emotionally stable will probably be more consistent, even-tempered, and tactful in their responses. High conscientiousness stands out as particularly important. Namely, it may increase the odds that the participant will complete all of the procedures in the first place; improve the quality and reliability of how they describe experiences, especially after the fact; and allow them to draw on a larger pool of experiences since they are more likely to seek a heavy workload.

This line of reasoning additionally raises questions about self-selection among research subjects. It is maybe not surprising that these two subjects signed up for and completed the study given their personality tendencies. But there are surely other prospective subjects who have personality traits that might engender very different kinds of workplace experiences. These same traits could also make them less likely to sign up for a research study of this type, be less than truthful, or respond inconsistently. How to recruit and collect data from such students is an open question.

As a final note on personality, we observe that both participants self-reported high extroversion. Yet this did not seem to predict verbosity, as Sophia proved much more expressive than Mary in both the reflections and interviews. On the other hand, simply probing about personality led both Mary and Sophia to mention that specific characteristics often associated with extroversion (e.g., assertiveness, a lack of social reserve) were potentially a liability or difficulty for them at work. Further investigation is needed to examine this dynamic, including to see if it is more widespread

among early career engineers and/or is related to other characteristics such as gender. But even more generally, our results help show that personality-related prompts can be highly generative.

Our continuing research efforts will address such themes. In fact, this paper represents a first step toward analyzing reflection and interview data from six engineering students in total. We will also be comparing these results with findings from a larger group of research subjects who were only interviewed. We intend that this process will further enhance our understanding of early career practice through the lens of boundary spanning, while establishing whether some of the insights and implications discussed in this paper hold true in the larger data set. Nonetheless, the preceding account provides strong preliminary evidence that the combination of data collected in different ways over a longer time can provide a view of professional practice that is richer and more nuanced than what can be obtained through the use of reflection or interview data alone.

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