Leading from the Bottom Up: Leadership Conceptions and Practices Among Early Career Engineers

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Introduction

The engineering profession in Canada and the United States is changing in response to numerous global forces, and this in turn is affecting engineering education. One response by engineering educators has been to introduce leadership education [1],[2]. However, very little is known about the development and practice of leadership among engineers in the workforce. Even less is known about early career engineers, who are in the period of training before they gain their professional license. To date most research has focused on investigating leadership behaviours and development among undergraduate students [3],[4] or senior engineers [5],[6]. We are filling a gap by investigating leadership among early career engineers. Our specific research question is “What does leadership development look like at this career stage?”

Through qualitative analysis of semi-structured interviews, we show how early career engineers work to achieve coherence in their ideas about leadership. Some engineers show a disconnect between conceptions of leadership, opportunities to display it, and leadership behaviours. Others demonstrate more integration and coherence, and as a result have more successful transitions to the workplace.

The paper is organized as follows. First, we review the literature on engineering leadership in the workplace, highlighting why it is important to study leadership at this specific career stage, leading into our conceptual framework that highlights the interplay between leadership conceptions, behaviours and opportunities. We outline our methodology for data collection and analysis, and situate this paper in a broader multi-year research project and then we present an analysis of our qualitative data through the lens of the conceptual framework and then use four case studies to bring the findings to life. We close with a discussion of the findings and some implications for practice in both universities and the workplace.

Literature Review

The scholarly field of engineering leadership is relatively new, and much existing research focuses on university-based programs and experiences. This literature review builds on three other bodies of research: (1) General theories of engineering leadership in the workplace across all career stages; (2) Research on leadership in the hiring and recruitment of early career engineers; (3) Literature on the socialization and workplace adjustment of engineers.

Engineering leadership in the workplace

Early empirical research on engineering leadership in the workplace acknowledged the lack of a clear theoretical base, and so turned to grounded theory to generate one [5]. One of the key findings was that engineers have an aversion to the word leadership. However, when reframed as professionally relevant forms of influence, three distinct orientations to leadership emerged from the data: technical mastery, collaborative optimization and organizational innovation [5]. Follow-up work built on that framework and showed how individual engineers display these orientations
to different degrees at different career stages, based on their own learning and development as well as their changing roles and positions within organizations [7]. A survey focused on the behaviours of 175 engineers revealed that early career engineers, that is, those with zero to two years of experience, showed a strong orientation toward collaborative optimization [7]. A more recent paper showed how engineering leadership is viewed differently depending on who is perceiving it [6]. The paper highlights perspectives of engineering interns who did not see themselves as leaders. Interns instead focused on the role of their mentors in supporting them to overcome the theory-practice gap as they worked through workplace challenges. Both of these studies indicate there are unique leadership dynamics that apply to early career engineers.

Another study from the leadership literature presents helpful perspectives on the practice of engineering leadership. Alvesson and Jonsson (2016) conducted an in-depth single case study of a middle manager in a large, international manufacturing company, completing ten interviews and eight observations of the manager in meetings [8]. Their findings challenge the dominant perceptions of leadership in the literature which are based on “assumptions of coherence, integration, context and direction” (p.13). Instead, the researchers found fragmentation between the manager’s leadership ideas and practice, with noticeable differences between espoused leadership meanings and their actual use in practice [8]. This paper adds depth and richness to our understanding of leadership, but its focus on an engineer in a position of leadership does not tell us about the process of leadership development at an early career stage.

Overall, these studies provide us with a set of distinct engineering leadership orientations to look for among engineers. They show that leadership is not a fixed concept, especially for engineers, and that even a single individual may hold contradictory perspectives about their own leadership. However, beyond some basic patterns, such as early career engineers tending towards collaborative optimization behaviours and interns not seeing themselves as leaders, we need to look elsewhere for research that specifically focuses on early career engineers.

Hiring and recruiting for engineering leadership

A second body of literature investigates the hiring and recruitment practices of engineering companies. Hartmann and Jahren (2016) distilled five themes for leadership among early career engineers based on analysis of job descriptions and subsequent interviews with hiring personnel at engineering companies [9]. These five themes are: initiative/confidence, communication, interpersonal interactions, teamwork, and engagement. They later developed an instrument to validate the five leadership themes “to understand the needs of industry” (p. 1). The Human resource professionals surveyed showed a clear preference for the first three behaviours: initiative/confidence, communication and interpersonal interactions [9].

Research from Handley, Lang and Erdman (2016) investigated the perspectives of on-campus recruiters who were looking for leadership among engineering students in their final year of studies [10]. They found that recruiters were seeking students who had been involved in activities outside the classroom and had the ability to articulate the learning gained from these experiences. The three engineering leadership themes they identified were communication (self-awareness), connection (big picture thinking) and confidence [10].
These studies are valuable because they shed light on employer perspectives of desired leadership qualities and behaviours of entry-level engineers. However, they do not include the perspectives of engineering graduates themselves, and they are restricted to looking at expected displays of leadership, rather than its actual practice.

**Workplace adjustment and socialization of engineers**

The last body of literature looks at the workplace socialization and adjustment of early career engineers. A few key studies from organizational psychology, learning sciences and human resources looked specifically at engineers. Korte’s (2009) study on the socialization of newly hired engineers “investigated the experiences of 30 newly hired engineers during the early stage of their employment with a large manufacturing company” (p. 285) [11]. He found that relationships with colleagues were the primary driver of socialization and adaptation to the workplace, with the immediate work group forming the primary context. This challenged some of the core assumptions of organizational sociology, which puts more weight on organizational structures and the role of formal line managers. Korte also contributes a helpful summary of key variables from recent models of organizational socialization (pp. 286-287) [11]. In particular, variables from the 2007 study by Ashforth, Sluss and Saks [12] include “proactive behaviours” of newly hired employees, such as information seeking, feedback seeking and building relationships (p.286). These studies point to the importance of relationship building and other proactive behaviours in making the transition to the workplace.

Our literature review highlights a gap that we seek to fill through answering the research question guiding this paper: “What kinds of leadership development occur among early career engineers?”

**Conceptual Framework**

Our literature review indicated some existing frameworks and thematic areas that serve as a good starting point for deductive analysis. However, we still needed our own conceptual framework to make sense of the different dimensions and aspects of leadership without being overly prescriptive or narrow. The paper by Alvesson and Jonsson (2016) in particular highlighted the inherent contradictions that can exist between an individual’s espoused leadership approach and their actual practice. With this in mind, we decided to organize our conceptual framework around three key perspectives: an individual’s conception of leadership, the opportunities for them to enact leadership, and the actual leadership behaviours they display.

Table 1 summarizes the research on which this framework is based, much of which was already introduced in the literature review. There are two additions, Northouse (2010) and Ibarra (1999, 2015) which did not emerge from the initial literature review but were added to fill specific gaps in the conceptual framework. These are explained in the paragraphs that follow Table 1.

**Table 1: Conceptual Framework**

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<th>Leadership conceptions</th>
<th>Leadership behaviours</th>
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By leadership conception, we mean the implicit definitions or mental models through which individual engineers see the world and which help them identify what is and is not leadership. We attempt to distinguish leadership conceptions that are based on leadership as a position from those that were based on leadership as a process [13]. The former is based on traditional notions of a leader as an individual with power and authority based on their position within an organization or society. It was exactly this notion of leadership that was associated with the resistance encountered in our earlier studies. The latter, leadership as a process, has been articulated by many scholars, but we chose to use Northouse’s simple definition of leadership as “a process whereby an individual influences a group of individuals to achieve a common goal” (p.3) [13]. We also use Rottmann et al.’s orientations to engineering leadership: Technical mastery - “shar[ing] their technical problem solving skills with others through informal mentorship” (p. 7); collaborative optimization - “build[ing] effective and efficient teams across organizational units by learning about and leveraging their colleagues’ strengths” (pp. 7-8); and organizational innovation – “us[ing] entrepreneurial thinking to bring technically sound ideas to market” (p. 8) [5], [7]. It should be noted that the three orientations can be used to understand both leadership conceptions and behaviours.

Leadership behaviours refer to observable actions taken by individual engineers that influence change. Early career engineers may be demonstrating behaviours that others might interpret as leadership but that they might not see as leadership themselves. In order to examine leadership behaviors, we used Hartmann’s five engineering leadership themes for coding: initiative/confidence, communication, interpersonal interaction, teamwork, and engagement [9], [16]. We augmented this by coding for proactive behaviours from Ashforth et al.: information seeking, feedback seeking, job change negotiating, positive framing, general socializing, building relationships, and networking [12].

Leadership opportunities refer to the situations, roles and tasks that individuals perceive as relevant contexts in which they can practice leadership. To explore how early career engineers can create opportunities for themselves, we draw on the work of Herminia Ibarra who developed the idea of working identity and provisional selves to explain the experimental process by which individuals “test out” new roles and identities through a process of imitation [14]. Ibarra’s more recent work is more explicit about how this relates to leadership: “Act like a leader, think like a leader”[15] summarizes her controversial argument that leaders develop best by first creating opportunities to try out new behaviours on a tentative basis, and later develop the identity (or conception) of themselves as a leader after having demonstrated new behaviours and gathering feedback. Ibarra argues that individuals in organizations should create opportunities for themselves to start doing new roles without waiting for a formal promotion and new job title.
Taken together, these categories of leadership conceptions, behaviours and opportunities help us conceptualize leadership development among early career engineers. Each element can be used as a distinct analytical perspective, and we can also look at interactions between the categories for one individual. We do not presuppose a unidirectional relationship between the three. In our interviews, we asked how interviewees define leadership before asking them what opportunities they see for leadership. The conceptual framework gives us flexibility to notice when early career engineers are displaying leadership behaviours but not perceiving those as relevant to leadership as they define it themselves.

Methodology

This paper presents findings from one part of a larger, multiple-phase, mixed-methods study that examines leadership transitions throughout the career trajectory of engineers. The first phase investigated the engineering leadership transitions that take place during undergraduate education [17]. The current phase of research investigates the school-to-work transition of engineering graduates, while subsequent phases will focus on the transition from technical to managerial roles, including the lifetime reflections on career trajectories of engineers who end up in positions of senior leadership.

The current phase of the project analyzed the experiences of individuals as nested cases within four engineering companies. We used two main sampling criteria to select early career engineers for the participation in the study: (1) they should have completed their studies within the last five years and worked at the selected company for at least six months but no longer than four years; and (2) where possible, we aimed to diversify study participants by gender, race, ethnicity, discipline and years of experience. As part of the study, we conducted individual semi-structured interviews with early career engineers, their managers, and human resource professionals. For the purposes of this paper, we almost exclusively draw on interviews with twenty-one early career engineers in four companies.

We used deductive and inductive strategies to analyze the collected interview data. We developed a set of codes based on the theories in our conceptual framework. We read through interview transcripts and coded based on this set of predefined codes. In parallel, we noted emergent themes and created new codes to capture these patterns. For example, a set of codes were developed to capture the most common responses to a question on leadership opportunities: project lead, mentoring others, and committee participation.

To analyze leadership behaviours, we combined Hartmann’s five engineering leadership themes [9] with some additions from the organizational socialization literature. The bulk of the interview protocol was comprised of questions about how individuals navigated the transition to work, learned to navigate the culture, and figured out how to do their job. This meant there were significantly more data to draw on for this part of the analysis. We also coded with a set of individual proactive behaviours socialization tactics from Ashforth et al. [12].

Once we had coded the interviews, we looked for patterns in the frequency of codes across the analytic categories and across organizations. We chose a smaller number of cases for which to
develop individual case descriptions and more in-depth analyses of the interplay between different themes in context. We returned to the literature for clues that might explain some of the emerging findings, and found that the article by Alvesson and Jonsson (2016) in particular illuminated some of the complex dynamics at play [8]. Finally, the refined conceptual framework was applied to a smaller set of cases to highlight situations where early career engineers’ conceptions of leadership, opportunities for leadership, and practices of leadership were either aligned or disconnected. These are presented in a later section.

One limitation of the study is that the interviews focused mostly on the transition process. There were only three short questions on leadership at the end of the interview protocol, which were rushed in some cases due to time constraints. It is possible that interviewees might have provided more detailed answers had they been given more time. On the other hand, the fact that leadership was in the background may have helped us access a range of behaviours unfiltered by the strong connotations of the word leadership. This tactic builds on previous research [5] which ran into challenges when interviews focused explicitly and directly on leadership. A second limitation is that data for each case comes from a single interview. This fails to capture changes in perspective over time. In future papers, we will be able to triangulate using interviews with managers and HR professionals from the same companies as the early career engineers.

Findings

We have organized our findings to mirror the analytic process we followed. First, we share overall findings for all twenty-one cases for each of the three categories from the conceptual framework. Then we present four individual cases to show the interactions between the three parts of the framework, and to illustrate the broader findings through examples. These cases also bring to light the complexity of the interactions between case (individual) and context (organization).

Leadership conceptions

For leadership conceptions, most of the relevant statements were in response to the question “What does leadership mean to you, in your own words?” We used two different perspectives to categorize the responses.

The first analysis revealed that the majority of early career engineers had leadership definitions that centered on the position of leadership and the individual leader’s authority to direct people, set goals, and make decisions. This group tended to focus on management realities, making difficult decisions and sticking with the consequences, and having the right answer. A minority had definitions that solely focused on leadership as a process of influence [13], whereby leaders could act without being in charge, and support or help others through feedback and mutual adjustment. These process-oriented leadership definitions tended to focus on personal growth and learning more than management and results. A few individuals had definitions that included elements of both perspectives. Examples of all three will be explored in the individual cases.

We also looked for examples of engineering leadership orientations (technical mastery, collaborative optimization, and organizational innovation) [5]. This analysis revealed that the
most common self-conception was technical mastery, followed by collaborative optimization. A small number displayed organizational innovation. When we compare these findings to the survey conducted in 2013 with a sample of 175 engineers [7], we see an interesting difference. In the survey, the vast majority of early career engineers (zero to two years of experience) showed a preference for collaborative optimization, whereas in our interviews we saw a stronger preference for technical mastery. An important distinction is that the survey asked behavioural questions about how engineers act in different situations, whereas our interview questions directly asked people their definition of leadership in their own words.

**Leadership behaviours**

Leadership behaviours were analyzed from two perspectives. Using Hartmann and Jahren’s [9] themes, we saw a distinct pattern: The three most prevalent behaviours were interpersonal interaction, initiative and confidence, and communication. The other two themes, teamwork and engagement, were far less prevalent. This aligned with Hartmann and Jahren’s own findings from the United States, where initiative/confidence was by far the most highly valued competence [18]. The analysis of proactive behaviours using codes from Ashforth, Sluss and Saks [12] revealed that information seeking, feedback seeking and relationship building were by far the most prevalent. On the other hand, job-change negotiations and positive framing were quite rare. Networking was somewhere in between: it was particularly important in consulting companies where early career engineers had to build networks to get assigned to projects.

When coding interviews, many statements were coded twice – once for engineering leadership behaviour and again for proactive newcomer behavior. There was clear convergence related to interpersonal relationships, information and feedback seeking, and taking initiative with confidence. Many interviewees spoke about the importance of learning from other people face-to-face, not just from documents, textbooks or user manuals. This is a form of learning that is much less prevalent in engineering education, where individual content mastery is rewarded through individual examinations that provide economies of scale for assessment by instructors and teaching assistants. Early career engineers who appeared more effective at making the transition to work were able to build relationships, had the confidence to ask the right questions of the right people at the right time, and took initiative to build a network across the company beyond their immediate work group.

An unexpected finding is that there were limited examples of interviewees talking about teamwork. Given the importance placed on learning from others, and the fact that early career engineers are navigating the social structures of knowledge and expertise, perhaps they are not yet experiencing “teamwork” in the same way they did in university. As documented in the engineering education literature, many of the hands-on projects in engineering education take place within teams of relative ‘equals’ in terms of age, experience and knowledge base, and so teamwork is largely about learning to work together, learn together, share tasks, coordinate efforts and achieve a common goal [19]–[22]. When engineers transition to work, they have a more defined role in a larger organization, and at least initially may be more likely to be assigned tasks, given deadlines and required to play their part. The disconnect between what is considered teamwork at work and in school seems worthy of further study.
**Leadership opportunities**

Aligned with the prevalence of *positional* conceptions of leadership, the most common type of leadership opportunity identified by the novice engineers was “project lead”. This usually meant the individual was given responsibility for a portion of a project with some discretion about how to proceed. In some cases, engineers had developed expertise on a topic that gave them extra authority, while in others, they had people reporting to them for a defined project.

The second most common leadership opportunity mentioned by junior engineers was mentorship. In the majority of cases, entry-level engineers were mentoring co-op students and interns. Some more experienced early career engineers mentored their ‘juniors’ who joined the company after them. The question of whether mentorship is viewed as a leadership opportunity revealed a range of conceptions at play. Individuals varied in their perspectives from a narrow transactional view of leadership that excluded mentorship to a broad empowering view of leadership that embraced mentorship.

In the narrow view, mentorship is seen as merely answering questions of those who are more junior: “[Co-ops] would have questions and I would help guide them ... [but], there haven't been too many leadership [opportunities] yet.” This engineer is explicitly making a distinction between mentorship (co-op students asking questions and offering guidance) and leadership, with mentorship being purely transactional.

The middle ground view sees mentorship as a passive leadership opportunity: “We have co-ops that come in every 4 months, [and] I would say that there's opportunity to be a leader there. You show them the ropes.” This person did categorize mentorship as a leadership opportunity, but saw it as merely helping socialize the new co-op students rather than investing in their growth.

Finally, the broadest conception of leadership sees mentorship as an active leadership opportunity: “I really want to instill those values, … knowledge and expertise in [the co-op students] so they can be successful.” This engineer was excited and motivated to invest in the leadership development of others through mentorship.

The third category of leadership opportunity we found in our analysis was committee participation. This ranged from social to health and safety committees, and also included participation in company sports teams and professional development programs such as Toastmasters. There was less coherence in the size, scope and nature of opportunities in this category. However, the variable level of effort required and the opt-in nature of committees make these types of opportunities more accessible than the other two types. This was highlighted by one of the managers we interviewed:

“It’s very hard to get the leadership opportunities because you’re seen as a junior member... if I had to give advice to an [early career engineer], volunteer for other things. The joint Health and Safety committee, to organize the Christmas party, to get that leadership experience, but also for senior members of the company to see that you do have that leadership kernel, or the seed in you that just needs to get watered and let grow.”
Early career engineers have varying levels of control and influence to access leadership opportunities. Some opportunities can be uncovered by individuals themselves, such as volunteering for a committee, while opportunities, such as leading a project, have to be offered by the organization. Leading a project was both the most frequently cited and the most sought out by early career engineers, yet it remains outside of their sphere of control. In some cases, engineers were able to rationalize why they thought they had been offered or refused the opportunity to lead a project—based on personality traits, past performance, work ethic or relationships with managers. Organizations, through the actions of their managers and supervisors, facilitate or constrain the leadership development of their young engineers based on how they communicate opportunities and assign work.

Individual Cases

The cases that follow show specific instances of leadership conceptions, behaviours and opportunities that bring the findings to life through individual narratives. We selected these cases to highlight patterns we saw in the full set of twenty-one interviews. Robert Yin [23] argues that case studies are best suited for answering complex “how” and “why” questions when there are many more variables than data points. This meets the needs of our situation, as we seek to understand and untangle the complexity of leadership development among early career engineers. The cases allow us to see how individual engineers shape and are shaped by the organizational contexts in which they operate. In all cases, pseudonyms have been used and key identifying data has been omitted or obscured to prevent identification of the individual participants in our study.

Case 1 – Bethany

Bethany works in a small and nimble government agency that works at the interface between policy, industry and the public. The engineering unit that Bethany works in has a long and stable history of hiring long-term interns (12+ months) as a core part of their operating team, investing in these interns as full-time permanent employees. Many return to work for the agency full-time after graduation, other than in periods when there are hiring freezes. While there is a high degree of trust inside the agency, there have been increasing calls for accountability coming from outside, so emails and documents must be written as if they will end up in the public record. The organization has no explicit client like the private sector engineering companies, but the government ministry to which the organization reports to could be considered a kind of client. There is a greater focus on public stakeholders, which requires employees to host and facilitate frequent public consultations and present at regulatory hearings. Projects are thus “owned” internally and not subject to stringent time tracking the way they are in the consulting environment. Structurally, there are only two or three layers of hierarchy from junior engineers to the vice president. Directors assign engineers to a suite of projects that fit their interests, as Bethany describes:
“Each person ends up working on probably 5 or 6, at least, different projects at the same time… Depending on the profile of the project, you'll have perhaps an even more experienced person on that team and then you'll have some [interns] often on the teams and people in the middle as well. It's not really a manager-employee relationship. It's more of a collaborative type relationship with the teams there.”

Bethany’s job is centered on electrical engineering but also spans policy development and community engagement. She started working at the organization during a one year internship while studying electrical engineering. During that extended work term, she felt like she was “treated like a normal employee” and was given challenging technical modelling work. During slack time she took initiative, helped out on projects in other divisions, and ultimately was rewarded by her boss with a complex and mission-critical modelling assignment. She excelled technically, and became so integral to the organization’s work that she negotiated to work part-time during the final year of her engineering studies, and then came back full-time afterwards. Bethany displayed strong networking skills, and worked to develop a set of informal mentors for herself, including a colleague in another department of her organization:

“The senior [engineer] that I worked with there has just a wealth of knowledge. She has a PhD in nuclear engineering. She's something else. I feel like I gained a lot of insight from her as well.”

Bethany thinks “leadership is about guidance, but it’s also about being a team member. Showing support as well as being kind of a mentor to the team as well.” She conceives of leadership as a two-way process of guidance from a manager and feedback from employee. We also see in her story a clear example of technical mastery, as she is recognized for her expert knowledge and shares it willingly with colleagues:

“The project that I started on as a student… I have transitioned into being the leader of that. Not so much of a team. What started off as two of us and now it's just… me. I still think of it as a leading role because when it comes to talking with my manager he considers me the expert of it. I tell him what's going on and he trusts that I know the next steps for the project.”

This sheds light on the process of developing technical mastery, and can be viewed as a positive “upwards” cycle of leadership development: Bethany’s attitude and her strong leadership behaviours were recognized and acknowledged, so she was given a major opportunity to lead a project. She seized this chance, further improving both her technical and people skills in the process. As she gained expertise and was more trusted and respected by her manager, this reinforced her conception of leadership as a process. It also reinforced her own identity as a leader, even though she doesn’t manage a team. This builds on her past experience learning from others, and shows how she has grown into a respected engineer in her own right:

“Some of the relationships I developed as a student, the people are still here. When I get stuck, I go back to the same people and say, "What do you think?" In some cases, I've developed some more expertise in some areas so they come to me now, too”
Perhaps not surprisingly, Bethany demonstrates an expansive view of mentorship as a leadership opportunity, especially because she has experienced the positive benefits of an open and encouraging culture towards interns:

“Well, as new students come in, everyone becomes a mentor to the students. It's a collaborative thing and we're all part of their learning. It was more so true with students that came after me than the ones that are there now, but in terms of mentoring them I've been involved in that as well quite a bit.”

Bethany’s case shows how early career engineers can be given opportunities on the basis of their behaviours. It also highlights how leadership conceptions are absorbed through experience. Bethany observed the positive impacts of strong mentorship on her own transition and thus accepted the team culture towards mentorship of co-op students: “it’s a collaborative thing and we’re all part of their learning”. This aligns with Korte’s (2009) findings regarding the importance of relationships within the immediate group for socialization of early career engineers [11].

Bethany’s case gives us a clear example of a process conception of leadership that is aligned with her with leadership behaviours and opportunities. By paying attention to how this integration across conception, behaviours and opportunities is achieved, we notice the critical role of the organization in fostering a culture that treats interns like full-time permanent employees, and the role of managers in paying attention to early career engineers and assigning appropriately challenging work with adequate supports. At the individual level, Bethany took advantage of this context by taking initiative, building relationships, and demonstrating increasing technical competence.

Case 2 – Charlie

Charlie is a mechanical engineer working at a large multinational engineering consulting company that has undergone significant downsizing in recent years due to harsh economic conditions that have affected major clients. The company’s clients are more often private sector entities, who outsource their engineering design work to the company. The company offers engineering as a service, with work broken into chunks and billed by the hour. The competitive business context has created further pressure for employees to be “billable” on projects to justify their ongoing employment. The pressure translates into an internal “market” for work as engineers, junior and senior alike, must get themselves assigned to projects. All engineers will have a home group – in Charlie’s case mechanical – but they cannot expect work to come to them through their home manager. In months leading up to our interview with Charlie, junior engineers had been laid off – a fact causing much apprehension among remaining early career engineers in various parts of the organization.

Charlie was offered his full-time job after having previously worked with the project management group during a 4-month summer co-op placement with the company. His job offer stated that he would join the mechanical engineering group. However, Charlie was unexpectedly assigned back to the project management group when he started back at the company because of his prior knowledge of a specific client. This caused him some disappointment as he had been
excited to put his specific mechanical engineering technical knowledge to use. After a year, the client project wrapped up and he settled into his current mechanical engineering role.

Charlie’s leadership conception is that “a leader is someone who motivates people to achieve a common goal”. We interpret this as positional, especially when taken alongside his statement that leaders are “good at seeing the big picture and actually thinking things through”. This is supported by the leadership opportunities he saw for himself, such as getting to lead a small project in another country. In this position, with a very small team, he applied some of his learning about project management from undergraduate engineering. This perspective aligns with leadership as position, emphasizing management, delegation, tasks and results.

Charlie displays a middle-ground stance on mentorship as leadership, remembering the time that he “presented to all the co-op students”. His description of this presentation focused on him getting to speak to the students and tell his story, and did not emphasize any aspect of developing a mentoring relationship that supported the growth of others.

It is Charlie’s leadership behaviours, and the response from his supervisors, that are the most interesting. In recalling his own attitude early on at the company, he focused on how important it was to build relationships, interact with people and ask questions: “When I first started, I was really proactive about getting out there and speaking with people and meeting people and everything.” Charlie went on to describe an incident where he acted on this proactive instinct and went directly to an engineer in another engineering group to ask a question. Unbeknownst to Charlie, the head of that other group was in a major feud with his boss’s boss. His direct supervisor dealt with this in an abrupt way, which took Charlie by surprise:

“When you first start, you think you can just go talk to whomever, which is the way it should be. [However] it was kind of eye-opening. You have to be a bit reserved sometimes as to who you talk to, about what.”

This is an important change in outlook, and shows how an organization’s culture might influence the perceptions and behaviours of early career engineers. As Charlie reflected: “It's very tough for you to actually learn [if] you sit there and you're afraid to ask questions. Asking questions is huge.” By putting doubt into his mind about which questions he could ask of whom caused him to reflect on whether his leadership behaviours were appropriate, arguably hindering his development. On the other hand, it was also a useful addition to his mental model of leadership, revealing a political frame that he was not aware of: “Politics of the office was definitely completely new.”

The purpose of highlighting Charlie’s case is to illustrate the importance of organizational context to the socialization of new engineers as they experiment with leadership roles and figure out what is acceptable. It also shows us how an early career engineer’s behaviours can elicit feedback that then shapes their conceptions of leadership. In this case, it was Charlie’s supervisor who scolded him for stepping outside of the formal hierarchy to seek information and ask questions of another group. Had that interaction been handled differently, it might not have suppressed Charlie’s natural question-asking approach.
Case 3 – Milan

Milan is an electrical engineer who has worked for two years at a large and growing engineering consulting company with more than 50 offices worldwide. Like Charlie’s company, clients are a mixture of private and public sector, although the greater proportion of public sector clients mean that Milan’s company has experienced less of a downturn in recent years. Engineers still need to find their own projects outside of their home group to be billable and relevant. Milan’s home group is electrical engineering. Milan was the first new hire in a long time for his group, and soon afterwards there were “a spree of new hires” leading Milan to be “the most senior of the juniors” separated by only a few months from his fellow junior engineers. The pressure of the work environment means that managers are busy, so it is often up to new hires to teach themselves and get up to speed.

Milan had no previous experience with the company. He did one internship during his undergraduate degree, and took a gap year off after completing his studies. Milan’s leadership conception is captured by the quote below:

“Leadership is about decision making and making sure that before you make a decision, you take into account all the proper variables that you have at the time and the best information that you have at the time. After you’ve made it, if you can't fix it, you just stick with it because to flip-flop is probably worse… you have responsibility and you can delegate responsibility, but ultimately it falls back on you and supporting the people you’ve delegated to and making sure they’re not out of their depth or anything.”

This perspective is clearly positional, with a focus on decision-making, delegation and responsibility. He sees himself on the path to management: “There’s only so far you can get by being an engineer… There’s a higher peak with the management path”. Some of Milan’s focus on leadership as position appears to be linked to his own experience as chair of the electrical engineering club during his final year of undergraduate studies. He believes that specific experience helped him get his job, but on the other hand he is disappointed at not getting to exercise positional leadership in his new role: “I haven’t done much yet since I am on the bottom of the totem pole, but I find [that experience] helps me speak with people easier, and analyze the situation, and flow through situations better”. This statement exemplifies the belief that this paper’s title seeks to challenge: that young engineers cannot lead until they gain the experience, age and titles to hold positions of authority.

Consistent with this definition, Milan’s interpretation of leadership opportunities was strictly limited to being a project lead. He spoke excitedly about the opportunity of “being given free rein to do the design and interact with the client, interact with the contractor, interact with the vendor”. He had not done any volunteer engagement, and while he had mentored co-op students he saw this as helping, not as leadership.

Milan’s leadership behaviours match those from the literature and a pattern observed across most cases: He asked questions, he built relationships to be able to learn technical knowledge from different disciplines, and he showed initiative in teaching himself several key computer programs that are crucial to his job but that he had not learned in university.
Milan shows consistency in his belief that leadership is equated with management and the use of positional authority to make decisions and delegate responsibility. However, he shows a disconnect in that he displays some strong mentorship ability and tendencies: Milan sees the importance of mentorship with co-ops being a “two-way process” and he admired another engineer who uses the “Socratic method” to get co-ops to come to their conclusions through questioning. On the other hand, when pushed on whether mentorship counts as a leadership opportunity, he firmly said “no”. In this sense, his narrow definition of leadership limits his perceived opportunities, as exemplified by his statement about being at the bottom of the totem pole.

Milan’s case highlights a very strong positional conception of leadership, and how that strong personal belief maps directly onto the identified leadership opportunities, which were more limited than others in our study. The disconnects in Milan’s leadership perspective arise in two ways. First, his demonstrated mentorship behaviours and uptake of mentorship opportunities are not integrated into his leadership conception in the way that Bethany has. Second, his positional conception means that he currently sees very few leadership opportunities. What is interesting is that Milan uses his experience as a student in a position of leadership to reinforce his mental model that leadership means being “the” leader. This example challenges some of the broad assumptions often made about the widespread benefit of student leadership experiences in supporting transferable skills.

Case 4 – Aaron

Aaron is a civil engineer working at the same large engineering consulting company as Milan but in a different engineering group in another office. During his studies as an undergraduate civil engineer, he completed a one-year internship with the company, and was offered a job to return after completing his degree. He delayed taking up the offer to complete a 1-year master’s program to deepen his technical knowledge in transportation systems engineering. Aaron’s civil engineering group recently moved to a new office that brought together transportation engineers and planners in one place:

“Now this building, the floor, is a hundred to a hundred and fifty people. It's more people. Most of our groups are working on the same floor. It's a lot easier to work with people to have these social events. Instead of doing a social event with your ten-person team, you're now doing it with forty, fifty people. You're all working together on the same floor. We do larger social events now. A lot of people communicate with other groups a lot more than we used to.”

Aaron’s definition of leadership is “taking initiative, going the extra mile… but also being able to relinquish leadership and support others to take the lead.” In both this statement and other examples from his interview, Aaron exemplifies conception of leadership as organizational citizenship, which draws on the process conception, but is qualitatively different. He shows an orientation towards collaborative optimization, as demonstrated in his approach to building teams and different people’s strengths:
“Being able to learn on the job … showing that you have something to give, whether if it's in a meeting or when you're completing a document or report, you really want to show that you're bringing some sort of value. If I'm working on something with three other people, I generally know that this person is good at this, this person brings this, they bring that. What is it that I bring to the table?”

Aaron built on his technical expertise and excellent relationships to earn opportunities to lead projects because of his background knowledge. He describes his process orientation to leadership which is effective even in the absence of a formal title:

“I would almost consider myself as the unofficial deputy project manager. We have about seven or eight ongoing tasks… even the project managers are only involved in certain tasks. I'm the only one that's part of every single task we work on. Whether it is the technical side of it, or even the project manager role of it, so scheduling meetings, doing minutes, budgeting, scheduling, and then doing the technical work. I've sort of been involved in all of those.”

Through these examples, Aaron displays many of the leadership behaviours from the literature: strong interpersonal interactions, information and feedback seeking, networking and communication. Aaron’s case shows us how consistent expression of leadership behaviours develops trust with managers and can lead to being offered leadership opportunities. He also showed self-awareness in knowing why his behaviours were effective, and actively shared this tacit knowledge with co-op students, as demonstrated by the quote below:

“I like to have an understanding of the whole big picture. I like that [also] with our [co-op] student. She was actually saying, ‘So here were like fifteen columns [in excel]. What was said in here? What is this one? What are all these comments for?’ She was trying to get an understanding of what the background of the project was, which I thought was pretty interesting. Even if I'm not working on a specific project, I'll generally ask questions about it to learn about what we're doing.”

The purpose of including Aaron’s case is to show how two early career engineers in the same organization can have completely different leadership conceptions and experience different opportunities. Aaron focused on his own technical learning and growth, and was rewarded with the opportunity to informally lead projects as a deputy project manager without any formal authority. This shows that while organization structures and culture play a major role, they do not explicitly dictate behaviours or outcomes. Also, it highlights the differences within companies, as different engineering groups have their own sub-cultures and norms.
Discussion

One characterization of leadership development based on this research is that it is highly varied, complex and often conflicted. As Alvesson and Jonsson conclude from their study of a single engineering manager: “We wish to stress in particular the need to take into account the divided and multifaceted, as well as the ad hoc, aspects of leadership attempts and efforts” (p. 16) [8].

Leadership conceptions can be understood as being along a continuum from more position-oriented to more process-oriented. Milan represents a strong position orientation, Aaron and Charlie are closer to the middle, while Bethany represents the other end of the spectrum with a strong process orientation.

Relating these cases back to our larger sample of twenty-one engineers, we saw many more examples of positional and mixed conceptions than we did process. It is not clear from our data what all the factors are that shape people’s leadership conceptions – Bethany pointed to her manager as an influence in her process definition, while Milan clearly linked his positional perspective to his extracurricular experience in university. Other engineers also linked their leadership experiences in university to project management opportunities, indicating a potential pattern. However, more research is needed to investigate how leadership conceptions and identities developed in university [17] transfer and translate into the workplace, particularly given their important role in filtering and selecting applicants [10].

Leadership behaviours were more similar across the engineers in our study. Our four cases align well with the broad patterns from the full data set, with almost all individuals demonstrating initiative, interpersonal interaction, communication, information and feedback seeking, and relationship building. When we consider how these behaviours align with the leadership conceptions, we can see that many of the behaviours are more aligned with process conceptions of leadership. There were few behaviours that we coded for that emphasize actions associated with positional leadership like delegation, decision making, use of authority and power, etc. This presents the first disconnect – early career engineers who espouse positional leadership are not exercising many of the behaviours that align with that conception because they do not yet occupy positions of leadership largely because of their career stage.

There are important interactions between behaviours and conceptions of leadership. Charlie’s case highlighted how feedback can affect one’s perception of leadership, causing young engineers to defer to those above them in the hierarchy and accept a positional conception of leadership. Bethany’s case showed the impact of an organizational context that supports mentorship, as her mentor with a PhD in nuclear engineering influenced her tendency towards technical mastery. Aaron’s case showed how recognition of his leadership behaviours by managers helped him solidify the notion that he could lead through his knowledge rather than the explicit formal authority of being a project manager in title.

Leadership opportunities aligned well with many of the behaviours exhibited, however the way that engineers perceived and valued the opportunities in front of them was distinctly coloured by their conception of leadership. Many individuals, like Milan, had positional conceptions of leadership, were oriented towards technical mastery, and saw project leadership as the best
opportunity. A reasonable conclusion is that if individuals can broaden or expand their conception of leadership, it might lead them to see more opportunities which allow them to enact behaviours more confidently, thus creating connection in their conception of leadership and possibly even their leadership identity. This is best exhibited by Bethany, who showed a cycle of growth and reinforcement as behaviours led to opportunities which reinforced a process conception of leadership. Perhaps the realm with the most potential for changing mindsets is in relation to mentorship. If early career engineers who value positional leadership more than process can be convinced of the real benefits and impact of deeper mentorship relationships, this may increase their motivation for such opportunities.

Implications for Individuals and Organizations

The purpose of this research is to explore what leadership looks like at the very beginning of an engineering career. At the same time, given the lack of empirical research on early career leadership, we want to offer possible avenues for action. These proposed actions are hypotheses, not recipes for success, and include suggestions that can apply to individuals and to organizations.

For individual early career engineers the core challenge is to broaden their conceptions or definitions of leadership. This could be approached through an internal process of self-reflection and analysis, but it could also be supported by dialogue and exchange with others – whether friends, family, peers or supervisors. By thinking and talking about leadership definitions and identities, assumptions can be challenged and perspectives widened. Opportunities for leadership may also be expanded. Within the limits of existing roles and structures, Ibarra argues that one can still experiment and create small opportunities for oneself by looking for ways to expand one’s scope of work [15]. Lastly, there are a number of common leadership behaviours that early career engineers can practice. Building relationships, seeking information and feedback, and asking questions are all important ways to learn to be effective in a new job and a new organization. These and other behaviours, such as building networks, help expand one’s perspective on the bigger picture of the organization’s work and one’s contribution to that larger purpose. Some of these behaviours can be encouraged and rewarded better within a university context.

Organizations should continue to create opportunities for early career engineers to display leadership. By trusting entry-level engineers with challenging assignments and developing supports like informal mentorship, organizations can display their trust in the leadership potential of their newest employees. A more challenging domain for organizations is how to shift or expand the leadership conceptions of their young engineers. Perhaps what is really needed is an available pool of opportunities to lead regardless of formal position. We think that facilitating conversations on this topic is a useful starting point. Our experience is that by hosting leadership workshops with buy-in from key engineers, organizations can let engineers share their perspective on leadership while being exposed to relevant research. Lastly, organizations can shape leadership behaviours through their culture, including the feedback they provide and role modelling by more experienced employees and managers. These suggestions are summarized in Table 2 below:
Table 2: Suggested actions for individuals and organizations

<table>
<thead>
<tr>
<th></th>
<th>Individuals</th>
<th>Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>-Reflect&lt;br&gt;-Talk to others&lt;br&gt;-Widen perspective</td>
<td>-Facilitate conversations, formal and informal to clarify concepts&lt;br&gt;-Host workshops (lunch &amp; learns)</td>
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<tr>
<td>Conceptions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leadership</td>
<td>-Observe&lt;br&gt;-Ask questions&lt;br&gt;-Build relationships</td>
<td>-Build a culture of feedback&lt;br&gt;-Support mentorship relationships in which behaviours can be modeled.</td>
</tr>
<tr>
<td>Behaviours</td>
<td></td>
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</tr>
<tr>
<td>Leadership</td>
<td>-Experiment&lt;br&gt;-Seek out new opportunities that don’t require formal authority</td>
<td>-Create challenging assignments&lt;br&gt;-Support mentorship, especially informal</td>
</tr>
<tr>
<td>Opportunities</td>
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Conclusions

This paper has presented a new conceptual framework for understanding how early career engineers develop their leadership. We found that early career engineers conceived of leadership more in terms of position than process, and more in terms of technical mastery than organizational innovation. Project lead positions and mentorship were the most common leadership opportunities. Importantly, all early career engineers displayed a wide range of leadership behaviours, even when they did not label these behaviours as leadership. The four individual cases selected show different combinations of conception, opportunity and behavior, and highlight how difficult it is to make simple claims about the relationships between these categories.

Future research should clarify the processes by which leadership conceptions, behaviours and opportunities interact. We recommend longitudinal studies of individual engineers embedded in their organizational context to trace learning and development over time. We also suggest gathering data using participant observation to learn more about invisible opportunities available to engineers, and to ask interview questions on concrete experiences. Vinson and Stevens (2016) bring some practical suggestions on how to do this within engineering companies [24], and the experience of Alvesson and Jonsson (2016) show that this approach is possible even in a large multinational engineering corporation [8].
References


