Counting Past Two: Engineers’ Leadership Learning Trajectories

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Abstract:

In the early 1950s, many science and technology focused organizations in the United States and Canada began to formalize a technical career track to accommodate the professional aspirations of engineers reluctant to abandon technical work for management [1-7]. While the resulting dual career track model—characterized by both managerial and technical ladders—remains dominant in human resource management theory, there is little evidence that engineers’ actual work experiences map on to two discrete domains [8, 9]. Our paper expands the dual track model by tracing the actual career paths and leadership learning experiences of 28 senior engineers in eight industries. We do this, not to better understand engineers’ career paths for their own sake, but rather to examine how engineers learn to lead in workplace contexts. In particular, we ask two organizationally related research questions: 1) What career paths do engineering leaders follow? and 2) How do they learn to lead along the way? After briefly reviewing the literature on engineering leadership development and engineers’ career paths, we introduce the situated learning perspective that grounds our work and present our findings in two parts. Part one characterizes six discrete paths—1) Company man, 2) Technical specialist, 3) Boundary spanner, 4) Entrepreneur, 5) Social impact change agent, and 6) Invisible engineer, and part two identifies salient leadership learning experiences that correspond with each path. We conclude by discussing the implications of our findings for engineering leadership educators.

Literature review: Engineers’ career paths as a site for leadership learning

Our literature review touches on two discrete bodies of research—one addressing engineers’ leadership learning opportunities and another highlighting engineers’ career paths. The first has been examined by engineering leadership educators over the last two decades and is likely familiar to the ASEE LEAD community, while the second dates back to the 1960s, is situated in two distinct social science disciplines, and is likely less familiar to engineering leadership educators. We briefly delineate the first, and then take a deep dive into the second. Our decision to revisit the literature on engineers’ careers from the 1960s and 70s is based on our belief that it forms a conceptually rich foundation for our under-researched topic of interest—engineers’ situated leadership learning experiences over the course of their professional lives.

Part 1: Engineers’ leadership learning opportunities

Over the last two decades—catalyzed, in part, by the US-based National Academy of Engineering publication, *The Engineer of 2020* [10]—engineering educators have begun to develop and evaluate formal leadership learning opportunities available to undergraduate and graduate engineering students. Most of this research involves program directors describing and assessing best practices in the context of their programs [11-20], with some taking a multi-
institutional approach [21-25]. A smaller, but growing community of researchers has surveyed industry leaders about the skills and traits necessary to become an effective leader, often concluding their studies with recommendations for undergraduate engineering educators about the intra- and interpersonal skills necessary to ease their students’ workplace transitions [26-38]. Finally, a handful of researchers have examined leadership learning in industry contexts by foregrounding formal professional development opportunities designed for high potential engineers [39-42]. These four lines of analysis provide us with important insights about engineers’ formal leadership learning opportunities in university and industry contexts. Most important among these insights is the finding that leadership can be taught. Unfortunately, by foregrounding formal education, they fail to address situated leadership learning—how engineers’ day-to-day experiences shape their development as leaders over the course of their careers. For this reason, we now turn our attention to the literature on engineers’ career paths.

Part 2: Engineers’ career paths

Most studies on engineers’ career paths are premised on a dual track model attributed to human resource managers in the 1950s who were motivated to institutionalize a technical incentive structure to improve the retention of high performing engineers [2, 4-6, 43, 44]. Stated simply, this model proposes that engineers can either: 1) ascend a traditional management hierarchy, gaining authority over larger numbers of employees with each step (management ladder), or 2) move through successive technical titles associated with salary increases, higher status, greater responsibility, and increased autonomy (technical ladder) [4, 7]. Goldner and Ritti’s classic contribution to the dual career track model is to examine the two ladders as a sociological phenomenon worthy of critical attention, rather than as a neutral incentive system [4]. While the authors concede that entry-level engineers may be motivated by a technical track, their findings highlight the power differential between individuals on the two ladders—leading them to conclude that the technical track provides employers with a mechanism to redefine failure along a managerial track as professional success. On the basis of their findings, they urge researchers to acknowledge the role of power when examining engineers’ career paths and be careful about presuming homogeneity in our understanding of the term “professionalism.” Roberts and Biddle similarly note a status disparity between engineers on technical and managerial tracks—with the latter experiencing greater mobility and remuneration for their work than the former [3]. Their examination of promotion patterns and performance appraisals of 2000 engineers employed by a large manufacturing firm in the Midwestern United States between 1978 and 1990, provides empirical backing for the existence of a dual track model—laying out the career transitions of engineers on technical and managerial ladders. Unfortunately, by presenting engineers’ career paths as a dichotomous choice between purely technical and purely managerial work, these studies construct leadership and technical work as mutually exclusive, homogenizing the experiences of individuals on each track.

By the mid 1980s, human resource management researchers began diversifying the dual track model—often in response to suggestions made by key informants in their respective studies. For example, Allen and Katz’ survey of 2,500 engineers employed by ten organizations in the United States revealed an unexpected finding that 48% of participants favoured challenging and interesting work assignments independent of promotion over both technical (20%) and managerial (32%) tracks [2, 43]. Like Allen and Katz, Watson and Meiksins found level of
challenge and intrinsic interest in their work to be central predictors of job satisfaction for the 800 engineers they surveyed in Rochester, New York [6]. Interestingly, and directly related to our focus on engineers’ career paths, the latter pair’s attention to engineers’ work values allowed them not only to track job satisfaction, but also provided them with a useful mechanism for testing the presumed mutual exclusivity of the dual track model. Their resulting typology of engineers’ work values presents four work orientations that are related but not reducible to engineers’ actual career paths: two traditional career orientations: “managers” (n=124) and “professionals” (n=154), and two hybrid orientations: “managerial professionals (n=112)” and “moderates (n=177).” Their findings suggest that while it may be useful to distinguish between engineers’ professional and organizational work values, it is not possible to neatly dichotomize their careers using mutually exclusive tracks. Nearly a quarter of the sample valued technical AND managerial orientations, while another quarter scored low on both orientations.

More recently, a small but growing body of literature has begun to highlight a wider range of engineers’ workplace realities. For example, Tremblay and his colleagues surveyed 900 engineers in Quebec, Canada in the early 2000s and found multiple, divergent career paths—technical, managerial, project-based, hybrid and entrepreneurial [8]. Compared to engineers on the two traditional paths, they found that project managers and those on hybrid paths quickly reached a pay plateau, and entrepreneurs viewed promotion practices in their respective organizations as unfair. The latter finding adds weight to Solymossy and Gross’ hypothesis that engineers become entrepreneurs to capture the potential value of their intellectual property [45]. Related to the theme of feeling undervalued by organizational promotion patterns, Hodgson et al. examined the engineering industry’s move to “projectification” from the perspective of project managers in South West England and Scotland in 2011 and found a gap between corporate promises of upward mobility for technically-driven engineers, and the lived experiences of project managers who had limited authority, increased administrative responsibility and a relative loss of technical status [46]. Taken together, these three studies indicate that engineers on the two paths privileged by the dual career track model (managerial and technical) enjoy a level of visibility, professional autonomy, upward mobility and decision-making authority rarely accorded to project managers, hybrid professionals, terminal middle managers, and those who pursue non-engineering paths. Tremblay, Solymossy, Hodgson and their colleagues succeed at tracking the differential reward system afforded to engineers on a diversity of career paths, but they remain silent on other dimensions of diversity within the engineering profession.

Only five of the articles we reviewed analyzed engineers’ career paths in ways that accounted for at least one dimension of demographic diversity—often gender [47-51]. Cardador and Hill surveyed 274 industry-based engineers in the Midwestern United States and found that female engineers on a managerial career path were at greater risk for professional attrition than their colleagues on other paths [49]. Their results are consistent with Fouad’s National Science Foundation study finding that 75% of women who left engineering were on a managerial path [50]. In a follow-up study, Cardador found that increasing female engineers’ access to management had unintended consequences for the women on these paths who reported feeling less like real engineers, working longer hours with less flexibility than female counterparts in technical roles. This finding challenges Goldner and Ritti’s claim five decades earlier that engineers on a managerial track have greater status, power and decision-making authority than those on a technical track. While it would be difficult to disaggregate the effects of gender and
generation, it would be worth examining whether Cardador’s “inverted hierarchy” (technical over managerial) holds true for all engineers, or only for women. Marinelli and Lord provide some insight into this question through their examination of 22 female, Australian engineering managers’ career transitions [51]. They found that most women were on terminal career paths leading to middle rather than senior management and that many of them were called in to lead during times of organizational transition, crisis or instability—making for challenging working conditions. Finally, Adams cast a wider demographic net in her survey of 620 engineers in Ontario, Canada and found that engineers who were lower in the management hierarchy, internationally trained, female and/or racialized reported poorer working conditions than their white, male, Canadian educated, senior leader counterparts [47]. Adams, Cardador, Fouad, Marinelli and their respective co-investigators remind us that by accounting for demographic diversity, we are not only behaving in a more inclusive or just manner, we are also creating conditions for more informed and accurate research about the leadership learning opportunities afforded to engineers through their respective career paths.

Together, our delineation of the engineering leadership learning literature, followed by a more extensive review of the engineering career path literature reveals a clear gap with respect to engineers’ situated leadership learning opportunities. Engineering leadership development researchers tend to assess participants’ short-term, formal learning outcomes in terms of skills, traits and competencies, while paying little attention to their longer-term organizationally contextualized professional pathways. In contrast, human resource management researchers and organizational sociologists tend to examine the characteristics and mobility patterns associated with different career paths while remaining silent on what study participants have actually learned along the way. Our study aims to fill this gap by tracing the career long leadership learning journeys of 28 Canadian engineers with at least twenty-five years of work experience.

Theoretical perspective: Situated leadership learning

The notion of situated learning is central to our investigation of senior engineers’ leadership learning experiences [52]. In contrast to the didactic learning opportunities students encounter in school, which follow a pre-existing curriculum and are tightly mediated by an instructor, situated learning opportunities are shaped by everyday practices and left largely to novices for interpretation. Lave and Wenger’s situated learning theory [52] highlights the type of learning that occurs in institutions—like workplaces—set up for a purpose other than teaching and learning, and thus provides us with a relevant analytic lens through which to study engineers’ leadership learning processes.

Lave and Wenger define situated learning as a process of “legitimate peripheral participation” (LPP) in a “community of practice” (COP). The first concept describes the process by which newcomers learn to become full members of a mature field, while the second depicts the mature, yet dynamic field within which this participation occurs. From their first day on the job, novice engineers absorb and are absorbed in engineering practice—in other words, they are legitimate participants (even pre-licensure) in a community of practicing engineers. They move from peripheral to full participation by actively engaging in their professional communities. These two concepts illustrate that learning is not simply about acquiring knowledge, using the tools of the trade, observing and imitating others, or picking up the skills and traits of experienced
practitioners. It is also fundamentally about direct participation in the history, activities and cultural life of the profession. As novice members enter communities of practice through legitimate peripheral participation, they pick up and reproduce existing traditions. This process of deeply contextualized professional development may seem like passive socialization to an external observer, but according to Lave and Wenger, it is actually a dynamic learning process mediated by an individual’s aspirations, goals and activities as well as the supports and constraints present in their respective workplaces. That is, while novice engineers may absorb traditional practices from their colleagues and teams, they enact these practices in their own ways with their own goals, strategies and histories, leaving new traces on their organizations and their profession, subtly reshaping community norms. By adopting Lave and Wenger’s situated learning theory as the foundation of our conceptual framework, we are choosing to make engineers’ otherwise implicit leadership learning journeys explicit. Unfortunately, while their theory is conceptually rich, it lacks operational definitions of key concepts and is thus difficult to use as a conceptual framework. In the next section, we supplement situated learning theory with five concepts highlighting the dynamic relationship between individuals and their respective environments.

**Conceptual framework: Situating leadership learning at the nexus of human agency and social structure**

The dynamic sociological tension between human agency and social structure lies at the centre of our analysis, with situated leadership learning becoming visible at the nexus of the two concepts. Please see Figure 1 for an illustration of the framework that shapes our research questions, methodological choices and analytic process.

Figure 1: Conceptual framework—Learning to lead at the nexus of structure and agency

We have operationalized the social structure end of our continuum using Lave and Wenger’s notion of a *community of practice* [52], and Billett’s notion of *workplace affordances* [53]. The first of these concepts represents the network of colleagues with whom engineers work, while the second highlights the features of their workplace that shape their respective abilities to achieve
their goals. Together, these two concepts tell only part of the story. That is, engineers whose work is fully prescribed by professional workplace norms could simply replicate existing practices through a passive process of professional socialization without needing to worry about leadership learning. Situating engineers at this end of the continuum would make the leadership feature of situated leadership learning irrelevant. At the other end of the continuum, we draw on Archer’s theory of human agency to highlight engineers’ priorities (ultimate concern), and the practical strategies they use to accomplish their goals (social project). Like was the case with social structure, these two concepts tell only part of the story—the story of engineers as leaders who can accomplish their goals independent of the situations they face. To the extent that individual engineers have the autonomy necessary to enact their personal priorities, the situated aspect of situated leadership learning is irrelevant. That is, with pure autonomy, situations would have no bearing on engineers’ abilities to achieve their goals. Please see Table 1 for definitions of the five key concepts that drive our analysis.

Table 1: Definition of key concepts shaping our analysis

<table>
<thead>
<tr>
<th>Concept</th>
<th>Source</th>
<th>Definition of Concept</th>
<th>Structure/Agency</th>
<th>Phenomenon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community of Practice</td>
<td>Lave &amp; Wenger, 1991</td>
<td>A mature field, populated by experts and novices engaged in work on a shared domain.</td>
<td>Structure</td>
<td>Professional network</td>
</tr>
<tr>
<td>Workplace affordances</td>
<td>Billett, 2001</td>
<td>Historically conditioned organizational factors that enable or constrain certain types of actions.</td>
<td>Structure</td>
<td>Opportunities &amp; Barriers</td>
</tr>
<tr>
<td>Ultimate concern</td>
<td>Archer, 2003</td>
<td>An issue of overriding significance to the actor at a given moment, in a particular context.</td>
<td>Agency</td>
<td>Priorities</td>
</tr>
<tr>
<td>Social project</td>
<td>Archer, 2003</td>
<td>Practical strategy through which we enact our priorities</td>
<td>Agency</td>
<td>Strategy</td>
</tr>
<tr>
<td>Legitimate peripheral</td>
<td>Lave &amp; Wenger, 1991</td>
<td>Process by which newcomers learn to become full members in a mature field of practice.</td>
<td>Nexus of Structure &amp; Agency</td>
<td>Situated Learning</td>
</tr>
<tr>
<td>participation</td>
<td></td>
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<td></td>
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</tbody>
</table>

In reality, engineers’ work lies somewhere between free agency and structural determinism. That is, professional engineers as a group typically have some level of control over their work, but their agency is mediated by a number of factors—organizational goals, the necessity to coordinate their work with others, relationships with clients, market forces, patterns of privilege within society, and the broader socio-political climate within which in they work. Because of these contextual realities, engineers who wish to influence their career paths, their organizations and/or society must engage in an ongoing process of situated leadership learning. That is, they must learn to lead in relation to the specific situations they encounter over the course of their professional lives. At the agency end of the continuum, leadership learning could be achieved through decontextualized skill building opportunities. At the structure end of the continuum, it could be achieved through professional socialization. Between these two poles, engineers learn to lead through a continuous, often imperceptible process of adapting their professional practices to the situations and contexts they encounter over the course of their careers—a process Lave and Wenger call legitimate peripheral participation [52]. This gradual, participatory process
cannot be easily accessed through large-scale surveys because engineers work in a wide range of contexts, have different priorities, and enjoy different levels of societal privilege. In short, they are a heterogeneous group of people who follow different paths. If we want to trace their leadership learning journeys, we need a more ideographic data collection strategy. We now turn our attention to the research methods we selected to achieve this goal.

**Research methods: Career history interviews with experienced engineers**

As one of our participants pointed out, “leadership learning is truly a journey.” (Maria, Boundary spanner, 85) In order to learn from this journey, we had to find a way to empirically tap it—something that could not easily be done using a survey or a set of focus groups with novice engineers. Career history interviews of experienced engineering leaders, interspersed with guided reflection, provided us with an interesting way to access implicit leadership learning over the course of participants’ three-to-four decade career histories [9, 54, 55]. It allowed us to ask questions about career transitions—something most engineers have a relatively easy time recalling—with follow up reflection questions about the leadership insights they gained along the way—something many of us struggle to define, particularly busy, task-oriented professionals facing pressure to complete projects in time and on budget.

When we asked direct questions about how participants learned to lead, most of them said one of two things; either “by doing it,” or “I don’t think of myself as a leader.” When we changed our approach and asked them to walk us through their careers, their accomplishments, their struggles, and what they learned about leadership along the way, however, we heard a diversity of deeply contextualized leadership learning narratives. Career history interviews provided participants with memory cues—allowing them to situate their leadership learning in the context of their project team experiences, their personal and professional aspirations, their formative growing up experiences and their organizations. In short, this data collection method provided participants with an opportunity to reflect on their careers, at the same time as it provided us with access to the situated leadership learning insights of senior engineers [52]. By privileging deeply contextualized leadership learning narratives over more traditional career path research methods—quantitative analysis of human resource records and large-scale industry surveys—we were able to generate a dynamic, empirical strategy to examine how engineers learn to lead over the course of their careers. This data collection method also provided us with a useful way to test the dual career track model.

Our sampling plan involved identifying 3-4 engineers with at least 25 years of experience in each of eight industries, deliberately diversifying by career path and demographic background. In March 2018, we sent invitations and project descriptions to key informants in four engineering-intensive organizations, asking them to identify 3-4 senior engineers with a range of career paths who had graduated prior to 1992. We also asked them to be mindful of demographic diversity where possible. The four organizations represented the following industries: Chemical processing, manufacturing, consulting/mining, and software. To ensure the inclusion of engineers who had followed less traditional paths, we also reached out to senior engineers employed in public service, finance, university leadership and social impact enterprises. In the end, 28 senior engineers consented to participate. Despite our intention to diversify our sample...
by demographics, it ended up being 71% male and 79% white, with a mean age of 58. Nearly 40% of participants had working class roots and 61% of them had completed a graduate degree.

We conducted the 28 two-hour interviews between May and November 2018, transcribed the audio-recordings verbatim and removed identifying features as per our institutional ethics review protocol. We also invited participants to share their resumes or CVs with us ahead of time to help us prepare for the interviews, and support our ability to meaningfully probe for career path details left out of their narratives. We then analyzed the data as a five-person project team. One member of the team thematically coded [56-58] the transcripts paying close attention to career patterns. She used qualitative evidence from the interview transcripts alongside job titles and dates from participants’ Curriculum Vitae (CVs) to distinguish between paths. After identifying six distinct career paths, she distributed transcripts to members of our inter-disciplinary project team, with each person taking responsibility for one or two paths. Our team of three engineers and two social scientists completed a data triangulation process by collectively analyzing a single transcript. The purpose of this process was three-fold—first, to support the development of novice qualitative analysts, second to ensure a level of consistency in our thematic coding, and third to become self-aware of our analytic predispositions. Once all team members felt comfortable with the coding process, we each took the lead on analyzing transcripts associated with one career path. Our subsequent meetings involved sharing our findings with team members and integrating their feedback.

Our analytic process involved two steps driven by each of our research questions. The first step foregrounded participants’ career paths, while the second foregrounded their leadership learning experiences. We began our analysis of participant’s career paths by identifying role transitions (technical to supervisory roles, middle to senior management roles, and movement into C-suite positions), demographic characteristics of each group (gender, race, age), time in each role, and mobility mechanisms (applied, tapped, groomed, leaped). We derived positional leadership transition categories from two sources—the job titles they listed on their CVs, and their response to the question—“please tell us about three significant leadership transitions in your career.” That is, instead of simply reading participants’ CVs and deciding where we believed their leadership transitions occurred, we began with their interpretations of transitional moments. In terms of mobility mechanisms, we used participants’ responses to interview questions about how they ended up in each successive position. Did they apply for a new role (applied) or where they encouraged by a supervisor to apply (tapped)? Were they identified as a high potential leader, and prepared for senior executive positions (groomed), or did they feel personally compelled to create a new role for themselves (leap)? We used this information to draw career path diagrams for each individual, and then used patterns within each group to generate six composite career path flow charts. The results of this process are presented in our first findings section.

Our second step involved qualitatively analyzing the 28 transcripts for engineers’ leadership learning experiences—first for each individual and then at the composite level for each group. For this step, we used a combination of inductive coding [56, 57] and the constant comparison method [59-61]. We highlighted all leadership learning moments in each of the transcripts, gave each one a descriptive name or code, compared and refined similar codes to generate thematic clusters, compared these clusters to key concepts in our conceptual framework, then identified patterns within and across the career paths. We concluded our process by identifying salient
leadership learning experiences for each group, and analyzing these findings through our conceptual framework. We report on the results of this process in our second findings section.

**Findings I: Counting past two career paths**

The 28 engineers in our sample followed one of six career paths, each of which required a blend of social and technical competencies—1) Company man\(^i\)\(^i\), 2) Technical specialist, 3) Boundary spanner, 4) Entrepreneur, 5) Social impact change agent, and 6) Invisible engineer. Please see Table 2 for the transitions characteristic of each path, as well as the demographic features of each sub-sample. Since the size of each career group was too small to meaningfully indicate percentages, we simply compared the demographics of each group to the sample as a whole. Recall, our sample was 71% male, 79% white, with a mean age of 58.

Table 2: Engineering leaders’ career paths

<table>
<thead>
<tr>
<th>Career path</th>
<th>Demographics compared to sample</th>
<th>Transition diagram (years/stage)</th>
<th>Mobility mechanism— early career</th>
<th>Mobility mechanism— later career</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company man (CM) (n=5)</td>
<td>Male White older</td>
<td>Technical (2) (\rightarrow) Project manager (2-7) (\rightarrow) Manage large projects (12-20) (\rightarrow) C-suite (5-15)</td>
<td>Tapped</td>
<td>Groomed</td>
</tr>
<tr>
<td>Technical specialist (TS) (n=6)</td>
<td>Gender = sample URM(^ii) Age = sample</td>
<td>Engineer in Training (2-5) (\rightarrow) Engineer (2-10) (\rightarrow) Project Manager (3-10) (\rightarrow) Technical executive (2-8)</td>
<td>Applied</td>
<td>Tapped</td>
</tr>
<tr>
<td>Boundary spanner (BS) (n=4)</td>
<td>Female White Younger</td>
<td>Technical (2) (\rightarrow) Project Manager (5-8) (\rightarrow) Lateral management moves (10-15) (\rightarrow) Senior integrative staff (1-5)</td>
<td>Tapped</td>
<td>Called in to handle mess (mid) Apply/leap (later)</td>
</tr>
<tr>
<td>Entrepreneur (E) (n=3)</td>
<td>Male URM older</td>
<td>Technical (2-4) (\rightarrow) Start up/CEO (20-40) (\rightarrow) Succession planning (1)</td>
<td>Leap</td>
<td>Grow alongside organization</td>
</tr>
<tr>
<td>Social impact change agent (SI)</td>
<td>Male URM older</td>
<td>Technical (1-4) (\rightarrow) Start up/new venture (20-30) (\rightarrow) Replication of venture in other contexts (10+)</td>
<td>Leap</td>
<td>Tapped to replicate</td>
</tr>
<tr>
<td>Invisible engineer (IE) (n=7)</td>
<td>Female Race = sample Younger</td>
<td>Entry level tech/finance/public sector (2-4) (\rightarrow) Gradual progression up hierarchy (15-25)</td>
<td>Applied</td>
<td>Encouraged &amp; Seniority</td>
</tr>
</tbody>
</table>

**Company men: Driving myself and others to win!**

I was never the type of person that would write goals down, but when I was on to something … we wanted to win. We’re pitching a business. We were going to do whatever it took, to the exclusion of a lot of other things. [winning not just for you but also for the organization?] yeah, just winning and prevailing (Alex, Company man, 624-628)
The Company men in our sample began their lives with modest means—often growing up as the children of farmers, immigrants or working class parents. Their competitive drive to excel, along with hard work, long hours, and a practical orientation to get things done resulted in early career recognition. Teachers and workplace supervisors quickly identified them as young men with potential and acted as their sponsors. They were trusted from early in their careers to manage large projects, and were eventually groomed for senior executive positions at the very top of their organizational hierarchies. Their professional identities tended to be intertwined with that of their organizations, signified by habitual use of the first person plural, to describe organizational objectives, contributions and impact. All five members of this group were white men, with four of the five over 60 years of age. Their stories reflect the promise of the American dream—upward mobility in exchange for hard work. The limited number of younger engineers in this group suggests one of two things: either it takes time to reach this level, or upward mobility in the context of a single organization is a vestige of an earlier time and place.

Technical specialists: Technical acuity is a powerful mechanism for influence in engineering-intensive organizations

There was news, saying our team managed to sell the [healthcare] software system to the whole country of X. ... So that's something I'm proud of on a personal level and on a team level. We eventually spent 18 months to finish this major rewrite. And it supported the company, literally brought the company to the next level. So after that, we were able to start landing deals with the big names. Among the top 10 hospitals in the States, I think nine of them are our clients now. (Hui, Technical specialist, 504-528)

The Technical specialists in our sample began their careers as highly driven technical problem solvers who were motivated by complex technical challenges. Half of them completed their undergraduate, and in some cases graduate degrees outside of Canada—often in China or Eastern Europe. All six members of the group completed graduate degrees in engineering, with more than half completing PhDs. While they were proud to contribute to the success of their respective organizations, their primary identities, affiliations and loyalties were with the engineering profession. They aspired to solve challenging problems and advance the state of the profession. All six technical specialists in our sample were committed to identifying and mentoring promising young minds. They assembled and protected the autonomy of strong technical teams, helping to refine the problem solving skills of their protégés. While this “nuts and bolts” [62] group is often represented in research as male, one third of the group was actually female, making it closer to gender parity than the company men, entrepreneurs and social impact change agents.

Boundary spanners: Connecting people, information & functions across sectors makes our organization better

The benefit to my organization of having this kind of [integrated] role is the variety of experience, the ability to influence projects because you can come at it from different perspectives. Not because you've been here a long time, but because you've tried different things so you're asked to be involved in this, or can you help with this? So I
think that it’s...that richness of experience, the willingness to try new problems to participate or contribute to those problems. I think those people are sought after. And I’m not unique. In the building there are other people like that. (William, Boundary spanner, 977-985)

The Boundary spanners in our group were recognized early for their technical competence and tapped by senior mentors for managerial positions. These four individuals—two women and two men—quickly vaulted past the typical onboarding processes experienced by “Engineers in Training” prior to licensure. All four were ambitious and driven to support the success of their respective organizations, but they were more collaborative than most of the engineers in our sample. They believed information was to be shared rather than protected and they found ways to use the large quantities of data at their disposal to enhance organizational performance. Like their technical specialist colleagues, they committed themselves to the professional development of junior engineers, often by establishing formal onboarding programs. Their reputation for empathic, collaborative leadership meant senior management often tapped them to clean up messy situations in times of crisis. They were widely recognized as competent, but their careers and confidence took a hit when the projects and business units they managed failed to meet traditional metrics for success. At the time of the interviews, the engineers we identified as boundary spanners had finally left the frustrating world of lateral role transitions, mostly through their own initiative. After being frustrated with what they viewed as terminal middle management roles, they either asked for a promotion or identified a new challenge that took them in a different direction. By the time of the interviews, all four were in senior leadership positions with integrative functions—often occupying positions created to take advantage of their diverse experiences across business units, sectors, and client groups.

Entrepreneurs: Leaping to better prospects

I was working at Company X. A job came up that I wanted. It was a plant manager job. I didn’t get it. I applied for it and I didn’t get it...so I resigned. The other thing was, I never thought of myself as a Company X employee. They never sold it to me. They had this savings plan. You could put X number of dollars in a savings plan, and they would match it 50%, and it would pay out in four years, if you were there in four years, but I never thought I would be there for four years. Economically it is the right thing to do, but I didn’t think I would be a Company X employee for the rest of my life.... I had aspirations to go into business...enjoy your job. It’s a one-way trip you’re on and it goes fast, so enjoy your job (Mickey, Entrepreneur, 19-24; 1704-1705)

The Entrepreneurs in our sample began their careers like engineers in the first three groups—as highly driven technical employees working for larger organizations. Within the first few years of their careers, however, these three independent-minded men became frustrated with the constraints they faced at work—bureaucratic regulations that restricted their capacity to innovate, organizational cultures that failed to align with their values, limited prospects for wealth creation, and difficulty gaining access to senior leadership roles at their expected pace. In short, after encountering barriers to success, they found another way forward. All three entrepreneurs found this “other way” while working for their employers. One came across a promising, market-ready product at his job in the chemical industry, another wrote a program useful to colleagues in
the health care sector that ended up being sought out by a growing number of international clients, and a third found an innovative way to bridge the professional development divide between academic and industrial communities. In short, all three created “win-win” situations for themselves and their clients. By the time of our interviews, their organizations had grown in size, market share, and impact. Interestingly, despite a two decade age gap, all three entrepreneurs were in the midst of succession planning—triggered either by a growing awareness of their own mortality or the promise of a merger, acquisition, or new direction.

Social impact change agents: Socially meaningful technology by accident, not design

In chemical engineering I was the first person that really did this kind of international development work by accident rather than by design. Professor X being the sharp lady that she really is saw that engineers have a huge opportunity to have an impact. (Paul, p 31 923 -928)

The Social impact change agents in our sample leapt into new ventures like the entrepreneurs, but were primarily driven by technical curiosity like the technical specialists. All three were male, and two of the three were under-represented racial minorities. As the career group title suggests, they were committed to social impact, but social justice was not the primary driver of their work. Rather, they were driven by technical curiosity and ended up in social impact roles after partnering with physicians, international development leaders and environmentalists who helped them identify socially responsive applications of their technically innovative ideas. They eventually took the lead on developing these initiatives and built international reputations for their work, refining their socio-technical solutions through iterative optimization in different contexts. Two of the three raised the profile of their technologies by influencing high-ranking politicians and donors to support their work, while the third found ways to subtly infuse social impact thinking into the organizational vision of his large, international engineering firm.

Invisible engineers: Mobilizing technical skills in non-traditional workplaces

I’m in a non-technical role, now. I’m an engineer, but am I really? Identity crisis!...I still struggle with that sometimes, and there’s a bias out there among engineers...I don’t think of myself as a traditional engineer, even from when I was in school, but I would say that I feel I can translate... There’s a senior director who’s very technical, and my senior director is not very technical. I have to form that bridge between them, and translate what she’s saying to him, and translate what he’s saying to her, because, otherwise, they’re not on the same page, and they don’t know what each other is talking about. I’m still trying to figure out my place in the world, but it comes once in a while. "Am I really an engineer?" "Yes, yes you are. Quiet down. You’re fine." (Donna, Invisible engineer, 668-680)

The Invisible engineers in our sample were no less driven or committed to technical problem solving than their colleagues, and about half of them led technical teams, but in contrast to the other 21 participants, they did not work in engineering-intensive firms. Rather, they leveraged their technical and system-thinking skills in public sector departments dedicated to housing, transportation, and infrastructure, or private sector financial institutions. Supervisors and direct
reports alike appreciated their problem-solving dexterity, collaborative approach to leadership, and ability to bridge understanding between technical and non-technical audiences. While some attained professional licenses, others struggled to meet strict provincial licensing requirements. After two to four years in entry-level roles, the invisible engineers gradually ascended a formal, multi-level hierarchy, demonstrating initiative at each stage. Many of them appreciated the transparency of their employer’s career pathways, but few believed this transparency resulted in fair promotion practices. Women, in particular, described gendered mobility patterns favouring male colleagues. The female invisible engineers’ explicit attention to gender contrasted with a general reluctance among other senior engineers of all genders in our sample to share their observations about inequitable reward systems. Gender aside, six of the seven engineers in this group experienced restricted mobility. In some cases—particularly within the public sector—they chose to restrict this mobility themselves in order to fly under the radar of elected politicians, while in other cases their mobility was externally limited by promotion patterns favouring graduates of business, law and political science. That is, their invisibility was part super-power, part constraint.

Together, these six composite profiles provide evidence that the dual-track model fails to account for the full diversity of career paths followed by actual engineers. While the experiences of the company men and technical specialists in our sample loosely parallel those of engineers on managerial and technical tracks—more than half of the engineers we interviewed found another way. These other ways resulted in divergent job transitions, mobility mechanisms and narratives. The quotations and group descriptions we shared above mark the six career paths as qualitatively distinct, but they say little about comparative mobility patterns between groups. Please see Figure 2 for a graphic representation of participants’ mobility patterns by career path.

**Figure 2: Mobility patterns by career path**

![Figure 2: Mobility patterns by career path](image)

The above figure reveals three important findings: first, all 28 of the engineers in our sample spent the majority of their careers in some kind of supervisory or management role; second, there are clear disparities in the terminal position attained by engineers across the six groups; and
third, the two groups who leapt out of their large organizations to establish a start up, spent the majority of their careers at the top of their respective organizational hierarchies. Together, these three findings supplement our career path narratives to suggest that while all participants experienced role transitions calling on them to manage if not lead others, they did so along qualitatively distinct career paths with divergent mobility patterns. We now turn to our second findings section to examine what they learned about leadership along the way.

Findings II: Leadership learning is a deeply contextualized journey

All 28 of the engineers we interviewed learned to lead through situated professional practice, often in ways that reflected path-specific patterns. In some cases their learning was catalyzed by powerful transformative events that were easy to remember such as crucible experiences [63], role transitions, stretch assignments, failed projects and proud moments. More often, however, they shared their sense of learning to lead gradually, through an almost imperceptible developmental process marked by observing mentors and role models, trial and error, ongoing professional practice, and adaptation to changing circumstances. The great multiplicity of leadership learning experiences shared by all 28 of the engineers we interviewed provided us with an incredible richness of overlapping leadership lessons that could fill multiple books. For this paper, we narrow our scope by foregrounding one salient experience shared by all members of each group, which was less common among members of other groups. We do so in a way that is grounded in our conceptual framework.

Recall our conceptual decision to locate situated leadership learning at the nexus of the sociological tension between human agency and social structure (Figure 1). We operationalized the social structure end of the tension using Lave and Wenger’s concept, community of practice, and Billett’s concept, workplace affordances—which we have characterized as engineers’ professional networks and leadership learning opportunities. At the other end of the spectrum, we have operationalized human agency using Archer’s concepts, ultimate concern and social project—which we have characterized as engineers’ priorities and practical strategies. Finally, we have operationalized participants’ situated leadership learning processes using Lave and Wenger’s, concept legitimate peripheral participation—which we have characterized as engineers’ gradual mastery process. Please see Table 3 for a summary of our analysis.

Company men: Adopting and achieving organizational goals by influencing others

I view my job as dropping little seeds all around, and then people will take those, nurture them, and grow something; and then give them the satisfaction that it was theirs. As opposed to saying, “well, you know what? I really told you to do that.” Influencing people is a big part of it and taking satisfaction from other people being successful is important as a leader. (Mitch, Company man, 785-799)

Senior executives recognized the company men in our sample early in their careers—sponsoring them for a wide a range of stretch assignments in what Vygotsky has termed their zone of proximal development [64]. That is, their assignments were challenging enough to push their development, but not so difficult that they were left floundering. Most came out of these experiences more confident and competent at both technical and managerial work. Through
increasingly challenging assignments, along with the trust and scaffolding of senior executives in their respective networks, they learned how to lead—adopting organizational priorities as their own. Over the course of their careers, with each successive step up their respective organizational hierarchies, they learned how to strategically motivate others to achieve organizational goals.

Table 3: Engineers learning to lead in the context of their careers

<table>
<thead>
<tr>
<th>Career path</th>
<th>Structure (network + learning opportunities)</th>
<th>Agency (priorities + practical strategies)</th>
<th>Leadership learning (participatory mastery process)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company man (CM)</td>
<td>Network of engineering executives sponsor successive leadership learning opportunities</td>
<td>Adopt organizational goals as their own, applying competitive drive and hard work to realize them</td>
<td>Learn to strategically motivate others to achieve organizational goals</td>
</tr>
<tr>
<td>Technical specialist (TS)</td>
<td>Tapped by mentors to manage increasingly complex technical project teams</td>
<td>Seek out their own work and mentor the next generation of technical protégés to uphold the professional autonomy of their technical teams</td>
<td>Refine social skills through mentorship, while leveraging technical acuity as a source of organizational influence</td>
</tr>
<tr>
<td>Boundary spanner (BS)</td>
<td>Lateral role transitions and successive “trials by fire” at the senior management level expose them to technical problems and networks across sectors, industries and units</td>
<td>Make themselves indispensable as key sources, disseminators and integrators of institutional knowledge</td>
<td>Broaden horizons, honing a diverse repertoire of context-specific leadership strategies—resulting in exceptional integration skills</td>
</tr>
<tr>
<td>Entrepreneur (E)</td>
<td>Large, bureaucratic organizations constrain their potential growth during early career stage—later career stage networks include potential funders, clients, board members and employees</td>
<td>Leap out on their own and build a thriving venture based on their strengths, constantly seeking out opportunities for growth while sustaining a strong workplace culture in line with their values</td>
<td>Learn to seize opportunities, honour their strengths, hire others to fill gaps, and trust the process of organizational growth</td>
</tr>
<tr>
<td>Social impact change agent (SI)</td>
<td>Network of physicians, international development leaders &amp; environmentalists help them realize the social impact potential of their technical prototypes</td>
<td>Test, scale-up, and replicate technical ventures across national and international contexts, improving local relevance and securing senior leadership buy-in</td>
<td>Learn to optimize social impact by blending technical imagination with political savvy and context sensitivity</td>
</tr>
<tr>
<td>Invisible engineer (IE)</td>
<td>Large scale projects involving technical and non-technical networks afford career development opportunities to engineers in non-traditional organizational contexts</td>
<td>Build and tap reciprocal, multi-disciplinary networks of specialists to collaboratively achieve a wide range of social, political, financial and organizational goals</td>
<td>Learn to communicate respectfully across disciplinary boundaries, recognizing and leveraging the expertise of their colleagues</td>
</tr>
</tbody>
</table>
A striking feature of this group was their consistent use of the term “we” to describe their organizations. More than any other group of engineers, the company men expressed a seamless union of personal and organizational identity. This may have been a product of their initial “fit,” as perceived by their sponsors, a multi-decade professional identity development process driven by their ongoing success, or a combination of the two.

Technical specialists: Carving out and mentoring a team of one’s own

I had a younger engineer that was working with me. He was an assistant on a job and I pushed him really, really hard...He’s very smart, similar to me, and I pushed him so hard that he burst in tears one day in front of me. I couldn’t take it. I think that’s one of the things...the relationship with the people, I cannot, if they are emotional, I get emotional as well, but I feel that I pushed him too hard and he didn’t deserve it. I didn’t mean anything bad. I wanted him to just...to be better. But he was in a different situation. I was not observant of the situation he had. Something private...[what did you learn from that?] there is always something underlying. If people are not performing, there is always something else, always. (Sasha, Technical specialist, 2263-2287)

The technical specialists in our sample began as high achieving engineers, who were tapped by mentors in their respective sectors to solve challenging technical problems and manage complex project teams. Their collective desire to uphold the technical integrity and professional autonomy of their departments often pushed them to recruit and mentor the next generation of promising young talent with the drive and vigour they had experienced from their mentors five to ten years earlier. As a group, they were appreciative of their mentors’ tough love approach and wanted to pay this favour forward to the young professionals on their teams. Most found out the hard way, however, that high intensity supervision could backfire—resulting in a combination of burnout, resistance and resentment among their junior colleagues. Over time, they began to appreciate that high potential novice engineers were not mirror images of themselves. Some technical specialists attributed differences between themselves and their mentees to Canadian cultural norms, while others spoke about differences in personality, formative growing up experiences and generational divides. Eventually, they learned to stop analyzing personality differences, and instead became more self-aware and compassionate, adjusting their own leadership styles to the expressed needs of their mentees. Repeated technical success following a gradual shift to more emotionally responsive supervision taught them to view effective engineering leadership as a product of both technical and interpersonal skills.

Boundary spanners: Broadening horizons

I learned that people are sensitive, which I already knew...and I tend to be a person who...I don’t carry a big hammer, right, I listen. I try to understand. I always try to collaborate and come up with a solution that’s good for everybody, but what I did learn from this experience is that sometimes you have to carry a big hammer, right? I still do a lot of listening but then I will just set rules. (Maria, Boundary spanner, 1547-1579)

The engineers in our boundary spanner group spoke about being most comfortable when they could lead by supporting people, listening to their needs, and making decisions on the basis of
consensus. Perhaps because of this democratic leadership style, they were often sent in to mediate challenging, emotionally charged situations that had deteriorated following acquisitions, mergers, and internal reform efforts. A handful of examples include being tapped to solve labour disputes in newly acquired plants, temporarily take the place of belligerent managers whose teams had fallen apart, replace business unit leaders whose projects had serious feasibility flaws, and repurpose employees of newly acquired companies to optimize their respective contributions to organizational priorities. In short, they were sent in to clean up other people’s messes. Like the engineers on a company man career path, the boundary spanners in our sample were recognized early as high potential engineering leaders and tapped for project management roles. In contrast to the company men, however, they were tapped for “trials by fire” rather than “stretch assignments.” Returning to Vygotsky’s *zone of proximal development*—they were placed in untenable, rather than challenging yet achievable, management situations. The impact on them, in a business context where success was measured by profit margins and billable hours, was a sense that they had failed. Rather than continuing to move up the hierarchy, they were tapped for successive lateral role assignments across sectors, business units and disciplines. On a positive note, those who actually managed, against the odds, to put out the fires to which they had been assigned, learned the widest diversity of context-specific leadership skills and strategies in our sample. These experiences broadened their horizons, resulting in extensive networks and exceptional integration skills across organizational units. While senior executives spoke about boundary spanners in appreciative (almost magical) terms, their high praise rarely translated into upward mobility. That is, the boundary spanners in our sample were rarely groomed for C-suite positions or promoted to lead thriving business units. This lack of material recognition wore on them over time and prompted them to initiate a promotion of their own—either by asking for one within their respective organizations or leaping to senior executive roles elsewhere.

**Entrepreneurs: Trusting the process of organizational growth**

*I think a metaphor is required. And I think the metaphor is of a garden. One starts with being a kid and planting a bean in an egg carton and watching it sprout. And then, as you go on you develop an appreciation for a wider variety of plants, and bigger scope of garden than the egg carton, and a wider variety of objectives for the garden. You include more people in your enterprise. The scope increases and you probably put some structures in the garden. You need to have a BBQ and places for people to sit and protection from the sun and trees that grow. Over decades you have maintenance activities that are regular and routine and satisfying. And then you have creative bursts. You build a shed, another shed, build a fence... (Aaron, Entrepreneur, 2058-2105)*

The entrepreneurs in our sample treated social structures as hurdles to jump rather than barriers to navigate. When faced with similar constraints to the other senior engineers we interviewed—restricted job mobility, limited salary potential, and bounded autonomy—they leapt out of their organizations and became self-employed. All three built thriving ventures based on their strengths, regularly seeking prospects for growth. As their organizations grew, they learned to recognize and seize opportunities, replicating strategies that had worked for them in the past. They hired others to fill organizational gaps and dedicated their own time and energy to establishing competitive advantage on the
basis of their organizational visions. They built extensive networks of funders, clients, board members and employees. Without exception, they were quite sociable, yet they characterized themselves as lone wolves. Other than teachers, professors, thesis supervisors and early career role models, they did not have sponsors or mentors in a traditional sense. One created his own pop up learning program by inviting “heroes” to lunch; another extrapolated leadership lessons from the performances of competitive athletes; and the third sought out professional development opportunities from a prominent management theorist. They never stopped learning or seeking out opportunities for growth. By the time of the interview, all were in the midst of succession planning—thinking about next steps for their organizations, and dreaming up new possibilities for themselves.

Social impact change agents: Blending technical imagination with political savvy

There was a huge role model there... outstanding visionary. He said that there are all these basic problems impacting children and women. In order to get the attention of a country... one has to go to the top. So, he went to the country to seek an appointment with the head of state. He wanted to elevate the discussion... I liked that model and I guess that influenced me. To get attention, you have to go to the top and get a commitment there and then it populates down. (Guru, Social impact change agent, 407-418)

Like the entrepreneurs, the social impact change agents in our sample leapt out of traditional employment arrangements early in their careers. In contrast to the entrepreneurs, whose success was primarily market-driven, however, the social impact change agents measured their success in terms of improved social conditions for increasing numbers of people. Professional networks of physicians, international development actors, and environmentalists opened doors for them by identifying practical implications of their technical ideas for under-served populations. The resulting inter-disciplinary partnerships provided them with an expanded client base to test, scale-up and replicate technical ventures across national and international contexts—leaving positive social change in their wake. They learned to amplify this impact by securing political buy-in at senior leadership levels, and increasing the relevance of their work on the ground. In short, they learned over the course of their careers, to blend technical optimization with political savvy and context sensitivity in order to maximize the benefit of their respective ventures to growing numbers of under-served communities at home and abroad.

Invisible engineers: Building reciprocal, multi-disciplinary networks

Around here, you don’t do a whole lot of things by yourself. It’s all teams. You depend on a lot of people that don’t necessarily report to you, and yet you find a way to help them out, and they want to help you out. (Carlos, Invisible engineer, 1064-1075)

The invisible engineers in our sample found themselves in regular contact with a wide range of technical and non-technical colleagues, clients, politicians and communities to serve. While those working in financial services were exposed to different organizational structures and
networks than those working in the public sector, all seven of the engineers in this group leveraged their technical skills in non-traditional contexts. Their success depended, not only on their ability to apply technical problem solving skills to non-technical problems, but also on their ability to gain support from a diverse group of colleagues, supervisors, team members, technicians, and in the case of those working in the public sector, community members and politicians. As they began to ascend their respective management hierarchies, they found themselves in charge of projects that could not feasibly be accomplished by one person—not only because the projects were large and complex, but also because they required ongoing coordination of specialists with different areas of expertise. These management challenges provided them with opportunities to learn and grow from the advice and support of individuals in their extensive networks. Over time, they learned to communicate respectfully and effectively across disciplinary boundaries, leveraging the expertise of their colleagues in pursuit of professional and organizational goals. While the invisible engineers had access to a wide range of formal, employer-sponsored leadership development courses, workshops and credentialing programs, most attributed their own leadership learning to situated professional practice.

Over the course of their careers, the 28 senior engineers we interviewed learned to blend social responsiveness with technical ingenuity in response to a wide range of situations and professional contexts. They not only experienced discrete career paths, role transitions, and mobility mechanisms, as we indicated in our first findings section, but also participated in different communities of practice, affording them distinct leadership learning opportunities. As a group, they learned to lead through stretch assignments, trials by fire, mentorship, organizational growth, vertical and lateral role transitions, managing large scale-multidisciplinary projects, and prototype replication in different contexts—with each of these experiences being differentially accessible to engineers on the six paths. They responded to these opportunities using a range of practical strategies that resulted, without exception in leadership learning along the way. Their learning paths were not set in stone, but they did follow six distinct patterns. The company men in our sample learned to motivate rather than drive others to achieve organizational goals, technical specialists learned to be more empathic when interacting with protégés, boundary spanners learned a diverse repertoire of contextually responsive conflict resolution strategies, entrepreneurs learned to set the course then trust the process of organizational growth, social impact change agents learned to supplement their strong technical skills with newly developed political savvy, and invisible engineers learned to productively collaborate with colleagues across disciplinary lines. In short, they all learned to lead by actively taking up opportunities afforded by their organizational contexts and their respective communities of practice. This suggests that leadership learning is not an add-on for high potential engineers. Rather it is an inevitable, if latent, product of their work. In the next section, we discuss the significance and limitations of our findings in relation to key themes in the career path literature.

Discussion

Our study contributes four key findings to the leadership development and career path literature: 1) there are more than two empirically available engineering career paths; 2) many of these paths blend technical and managerial responsibilities throughout engineers’ careers; 3) engineers can learn to lead without a formal curriculum or set of learning objectives, but it takes some time; and 4) specific leadership learning opportunities are differentially available to engineers on
different paths. The first of these findings supplements Tremblay et al.’s notion that engineers’ leadership transitions can take many forms [8]; the second enriches Watson and Meiksins’ finding that engineers’ careers cannot be neatly dichotomized using mutually exclusive technical and managerial work orientations [6]; the third contributes six distinct situated leadership learning paths to the engineering leadership development literature; and the fourth updates Goldner and Ritti’s finding that power is the ignored variable in studies of engineers’ career mobility structures [4]. What we have not yet done is examine the fourth of these findings in a way that accounts for demographic diversity. We do so now, taking our lead from Adams, Cardador, Fouad, and Marinelli and Lord [47-51].

Recall the mobility patterns by career path figure we presented in our first findings section—reprinted below. If we consider five levels in an organizational hierarchy to be Engineers in Training (EITs), Project Managers, Managers of large projects, Directors, and C-suite positions—the only three groups to reach the top level were company men, entrepreneurs, and social impact change agents. Engineers on the other three paths tended to peak in middle management or senior leadership roles. In terms of mobility mechanisms, only the company men were tapped then groomed for their roles. Engineers on the other five tracks were promoted through a combination of external recognition and self-driven mechanisms—suggesting a greater reliance on human agency for upward mobility.

Figure 2 reprinted: Mobility patterns by career path

An additional pattern becomes apparent when we map the demographic diversity of each group to the mobility patterns across groups. Men comprised 71% of our sample but 92% of the engineers with a C-suite position. Racial disparities were actually less pronounced with 75% of C-suite positions going to white engineers who made up 79% of our sample until we removed the 6 engineers who moved into a senior executive position through a personally high-risk leap. 100% of the engineers on our company man path, arguably the most privileged track, were white men. While our sampling plan does not permit us to test the statistical significance or generalizability of this trend, we must be mindful that women and under-represented, racialized
minority engineers in our particular sample of 28 senior Canadian engineers failed to reach the positional status of their white, male counterparts through learning opportunities structured by their respective organizations. This pattern needs to be tested with a larger, representative sample, as it may be partly explained by age. That is, the company men, with a few exceptions, were not only more male and white than the remainder of our sample; they were also older. Having raised this interpretive caution, we should note that in the teaching profession—which has exceeded 50% women since the late 1800s—career path researchers have demonstrated similar mobility patterns by gender—with women’s rise to leadership involving more circuitous paths, successive trials by fire, and political turbulence than their male colleagues [65-69]. Thus, rather than assuming that gender and race-based disparities in our career mobility findings are due to age and stage alone, it behoves us to empirically track the patterns by multiple demographic factors. Demographic disaggregation of career path data is a good idea for both methodological and pedagogical reasons as disparities in career mobility can translate into uneven opportunities for engineering leaders to develop, learn, grow and prosper. As educators, we have an obligation to equalize our students’ leadership learning opportunities. We conclude our paper with practical recommendations for engineering leadership educators after identifying the significance and limitations of our study.

Significance and limitations

Our study is limited in at least two ways. First, by interviewing 28 engineers working for eight employers, we lack the sample size and necessary representation—by industry, discipline, demographics, and organizational context—to generalize our findings to the full population of engineers in Canada. Second, by choosing to convert 28 divergent career paths into six composite profiles, we have artificially homogenized the experiences of engineers on each path. Given these limitations, it behoves us to point out that our findings are the product of patterns we observed within our specific sample. The six paths have not been institutionalized by any of the workplaces we studied, nor do the engineers we grouped together necessarily see themselves in these ways. In other words, the paths are neither real nor reified—we have socially constructed them to make the otherwise implicit process of situated leadership learning explicit.

Moving from limitations to significance, our use of composite profiles enabled us to identify patterns in deeply contextualized data that could not have been attained from large-scale surveys or individual narratives. As such, they function as a methodological midpoint between the level of abstraction and generalizability associated with nomothetic methods (large-scale surveys and experiments), and the level of specificity and resonance associated with ideographic methods (case studies and auto-ethnographies). The depth of our two-hour long career history interviews paired with guided reflection allowed us to identify a diversity of career paths lacking empirical precedent—something that we could not have accomplished using standardized survey questions. Similarly, our use of composite profiles and cross-case analyses allowed us to identify situated leadership learning patterns across career paths—something we could not have accomplished through case studies.

If situated learning matters, then it matters where engineers are situated. Similarly, if we are interested in leadership learning in particular, then it matters what engineers do in response to these situations. The central significance of our study emerged from our methodological decision
to connect engineers’ career transitions—a memorable set of events—with temporally related leadership learning lessons, making the otherwise implicit, gradual process of leadership learning explicit to the senior engineers in our sample. This data generation strategy enabled us to empirically flesh out the common sentiment among our participants that they “learned to lead by leading.” Further, our conceptual decision to locate leadership learning at the nexus of human agency and social structure allowed us to bridge a gap between two bodies of literature: engineering leadership development research which foregrounds human agency, and engineering career path research which foregrounds social structure. We now conclude our paper with recommendations for educators, researchers and employers interested in enhancing engineers’ situated leadership learning opportunities.

Conclusions & recommendations

Many of the engineers we interviewed described their occupationally embedded leadership learning as more powerful, relevant and authentic than formal leadership instruction, but as engineering leadership educators, we see an important role for university-based engineering leadership programs. Engineering workplaces, even those with excellent onboarding processes—are typically set up to sell technical services, not to teach novice engineers. Universities and colleges, on the other hand—even those that struggle to meet their mandate—are set up as institutions of higher learning. To the extent that we characterize university classrooms as purely technical domains, and relegate the professional development of engineers to the workplace, we will be leaving leadership education in the hands of employers and supervisors—all of whom are busy doing other things, and some of whom resist the notion of engineering as a leadership profession [38]. The differently available nature of leadership learning opportunities across industries, organizations and even career tracks, has consequences for the quality and accessibility of engineers’ socio-technical development. This places an undue burden on small organizations, and does a disservice to our graduates, particularly those who find themselves on a career path outside the highly visible, dual track model.

By integrating leadership learning into the technical curriculum, engineering leadership educators can take responsibility for the socio-technical development of our undergraduate engineering students, potentially accelerating a process that would otherwise take decades of trial and error. When these programs are universally accessible to all students, rather than offered exclusively to an elite group of individuals who happen to “fit” with employer’s conceptions of “high-potential engineering leaders,” we are in a better position to equalize leadership learning opportunities for under-represented groups of engineering students. Many of the senior engineers we interviewed began by telling us they wished leadership-learning programs had been around when they were in school, and nearly half of them (CEOs included) claimed they did not yet self-identify as leaders. It is our responsibility as engineering-leadership educators to scaffold the learning of all our students so they do not have to wait until retirement to reflect on or develop this important set of professional competencies.

We can do this in a number of ways—all of them grounded in the recognition that engineering is a socio-technical, rather than purely technical profession [62, 70-74]. For example, we can use leadership inventories and personal reflection activities to help our students become more self-aware [75, 76], then use interpersonal team building activities to help them empathize with the
needs of others [77, 78]. Once they recognize themselves and their teammates as more complex than the notion of “human factors” might allow, we can encourage them to consider the broader social impact of their design projects [79-84], expediting the process by exposing them to social impact change agents through panel discussions, interviews and site visits. We can share our career path findings with students who are reluctant to think of engineering as a leadership profession—noting that all 28 of the senior engineers we interviewed had supervisory responsibilities within four years of being hired. Beyond motivation and skill building, we can share our findings about alternative career pathways with students who remain uninspired by traditional technical work [38, 85-87].

While our research is primarily geared at engineering leadership educators, we believe our findings are relevant to two additional audiences—engineering career path researchers and employers of engineering intensive firms. Our findings suggest that engineering career path researchers could contribute important insights to the leadership development literature by diversifying career track possibilities, examining the professional learning experiences of the engineers they survey, and disaggregating mobility findings by relevant demographic variables. For their part, engineering employers could contribute to greater equity, diversity and inclusion in the profession by making mobility processes explicit and fair. In particular, they could critically examine who tends to be tapped or groomed for senior roles, on what basis they are identified as having high potential, and what happens when they stop using presumed “fit” as a proxy for competence.

Together, these three groups of engineering leaders—educators, researchers and employers—have a role to play in disrupting dualistic thinking about engineering work. By “counting past two” [88] dominant career paths and explicitly scaffolding the leadership learning of all our students and employees, we are in a better position to collaboratively support the next generation of engineers, as they develop the competencies and confidence necessary to succeed as leaders. To the extent that we choose to do this work in university and workplace settings, rather than leaving it up to the particular communities of practice in which engineers may find themselves, we will be democratizing leadership learning opportunities for future engineers, promoting greater equity and excellence in the profession.

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References:


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1 All names of individuals and organizations used in this paper are pseudonyms. Participants were given the option to generate their own pseudonyms. The term after each name refers to the participants’ career path and the number(s) refers to the line number(s) in the source transcript.

2 The gendered nature of this term reflects the reality of the sample—all five engineers on the “Company man” path were men, compared with 50% of those on the Boundary spanning path and 43% on the Invisible engineer path.
Under-represented racial minority.

We generated this chart by identifying the average number of years it took participants to transition between five positions—Engineer in Training (EIT), Senior Engineer/Project manager, Manager of large projects, Senior Leader/Director, C-Suite (Chief Executive Officer, Chief Technical Officer, Chief Financial Officer), divided by the length of their respective careers. We felt comfortable using these five positions because they were present, in some form, at all eight organizations we visited—including the five relatively flat engineering-intensive organizations.

One of the invisible engineers did make it to the CEO level, but this was not a dominant pattern for the group. Also, she was appointed to this position at a time of transition following the removal of her predecessor who had been plagued by scandal. As a result, her leadership learning opportunities reflected those of the boundary spanners more than those of the company men, entrepreneurs, or social impact change agents.