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Ethics and Engineering Leadership: A Utilitarian Approach

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Engineering Leader Identity and Social Power

Introduction

The use of identity as an orienting framework in engineering leadership has enjoyed recent attention, as the field focuses on how to best train engineering leaders. Like leadership (and human development itself), identity models are "…complex, dynamic, and individual.." (Tallman, Hughes, & Schell, 2023, p. 1). An important development in our understanding of engineering identity was proposed by University of Toronto's Troost ILead group . They categorized engineering leadership identity into three distinct orientations—Technical Mastery, Collaborative Optimization, and Organizational Innovation. This provides a basic model for understanding how professional engineers perceive leadership. However, there remains a theoretical "black box" regarding the mechanisms by which these orientations actually leverage influence or power. This paper seeks to bridge that gap by applying French and Raven's Social Power Theory as an analytical lens to the Toronto framework. The Research Question asks, "How can engineering leadership identity be adapted to a social power lens be to more fully understand engineering leadership mechanisms?"

To address the research question, this conceptual paper will map ILead's Three Orientations onto Social Power Theory, resulting in a more detailed analysis of the motivations and beliefs fundamental to engineering leadership. To synthesize these theories, this paper will adopt the methodology of theory integration established by Jaakkola (2020). This methodology is based on four different approaches: Theory Synthesis, Theory Adaptation, Typology, and Model. This research will adopt the Theory Adaptation model, which "seek[s] to amend an existing theory by using other theories" (Jaakkola, 2020, p. 23). In other words, the adaptation model is used to revise extant knowledge. The starting point in this methodology is the theory of primary interest, or domain theory (Lukka & Vinnari, 2014): Three Orientations of Engineering Leadership Identity (Rottmann, Sacks, & Reeve, 2015). From there, an alternative theory or frame of reference is applied, called "method theory": Bases of Social Power (French & Raven, 1959). From there, this paper will explore the Three Orientations using the lens provided by Social Power Theory. For example, how is Informational Power used within a Technical Mastery Orientation? In this example, the ambition is to leverage understanding of a Technical Mastery Orientation to engineering leadership, to understand how Informational Power operates within this domain. From here, the subsequent two Orientations (Collaborative Optimization and Organizational Innovation) will be likewise explored.

Following Jaakkola's (2020) methodology for theory adaptation, this study does not simply describe these orientations but recontextualizes them through the mechanics of Social Power. By deconstructing and applying the six bases of power—Informational, Expert, Referent, Legitimate, Reward, and Coercive—we can move beyond descriptive categories and toward a functional understanding of engineering influence. The analysis posits that engineering leadership is a unique manifestation of power, based on rational and structured motivations and values. By synthesizing these two frameworks, this paper provides a robust framework for understanding how technical professionals navigate the "soft" side of systems, leading to implications for engineering educators hoping to support leadership development.

Conceptual Frameworks

The Three Orientations of engineering leadership identity is firmly rooted in the reported experiences of practicing engineers. Identity providing a valuable lens through which to explore engineering leadership development, much of the engineering leadership literature has coalesced around their three-fold leadership orientation model. They furthermore outlined how this insight might be used developmentally, finding that avoiding the word 'leadership' and reframing leadership according to professional values were potentially useful pathways. In addition, they mapped their grounded theory onto a multitude of popular leadership theories-- outlining where leadership perspectives overlap and how leadership in engineering might be unique (Rottmann et al., 2015).

While this analysis provided a solid grounding for understanding how engineers position themselves as leaders, less was explored about the mechanisms undergirding the many leadership theories explored: for example, none of the included leadership theories provided a robust, comprehensive explanation or model of social interaction. Rather, the leadership theories mentioned each promoted a particular aspect of how leadership is practiced or perceived. For example, professions might reframe leadership to highlight key values in their profession. Or, Adizes's Methodology (1976) highlights how leadership functions based on organizational profile (from a contingency theory perspective), between managers and subordinates (Shiva & Hassan, 2016).

While these (largely position-based) models are helpful, drawing informed inferences about the mechanisms that drive leadership interactions must integrate a robust theoretical model of group dynamics.[1] Because little attention has been given to personal internal processes that might better inform engineering leadership dynamics, contributions from the organizational and social psychology fields have been left untapped. Pierro et al. (2013) argue that the leadership styles that populate much of the leadership literature are simply outlines of the many ways social power is exercised in various contexts. In sum, despite the value of Rottmann et al.'s research (2015), those wishing to understand motivations and beliefs of engineering leaders using a robust model of social interaction have little to inform them. The present work tries to fill this gap by exploring the relevance of Social Power Theory to ILead's Three Orientations.

Engineering Leader Identity

The domain theory that this paper will adapt is Rottmann, Sacks and Reeve's Three Orientations of Engineering Leadership Identity (2015). This qualitative constant comparative analysis explored how industry engineers perceived leadership in the profession. They adopted a grounded theory approach that outlined three ways leadership is exercised, sources of resistance to leadership, and practices for lessening that resistance. Important aspects of their three Orientations are key features (both technical and influential), level of influence, job satisfaction, and benefits to organization. The three Orientations are defined as follows:

1. Technical Mastery – "Technical expertise passed on through informal advice and mentorship." Subject matter expertise is of primary importance. Influence is wielded

[1] Group Dynamics is historically the realm of organizational or social psychology.

through mentorship, coaching, and other dyadic relationships. These leaders are motivated by a "lifelong honing of craft".
2. Collaborative Optimization – "Skilled facilitation of group process…" These leaders demonstrate interdisciplinary competence, as well as capability in facilitating interdependence and team cohesion. They primarily influence their team or the engineering department, often leading highly successful engineering teams.
3. Organizational Innovation – "Visionary realization of practical … ideas." These leaders exert the broadest influence in the company, potentially bringing products to market, from conception to delivery. They have extensive industry experience and can think about product development strategically (as opposed to reactively). They exercise their influence across the organization, as they strive to leverage their influence to accomplish impactful goals for the company (Rottmann et al., 2015, p. 9).

Two important problems in the engineering literature have been addressed by this model. First, this framework differentiates *'how engineers lead'* from '*how to lead engineers'*. This is an important step in understanding leadership development in an engineering context, as engineers serve on both 'sides' of the leadership dynamic. Second, the intent of the model is to provide a cohesive framework for engineering leadership education, rather than the existing piecemeal or skill-based approaches commonly used (Graham, 2009). However, it should be noted that the main focus of the research is how practicing engineers have come to view leadership identity in industry, not necessarily how they adopted and developed this perspective. Finally, the findings here are purely descriptive, leaving prescriptive questions about how engineers *should* lead unaddressed.

Social Power

"Social power is at the heart of group dynamics" (Pierro et al., 2013). Social power is defined as "…the *potential* for… influence" (Raven, 2008); related, leadership is defined as the "…*actual use* of power in effecting attitude or behavioral change" (Pierro et al., 2013). In the wake of Kurt Lewin's work on group dynamics, social power became an increasingly important concept in explaining the adult power field (Raven, 1993). This nascent field found its most lasting foundation in French and Raven's *The Bases of Social Power* (1959). This theory continued to develop over the decades (Raven, 1993), and it has been applied in a plethora of fields, including leadership (see Kovach, 2020 for a fuller discussion of the theory's many applications). In fact, it "…has been referred to as one of the most frequently cited approaches in the social power literature" (Raven, 2013, p. 180). Raven's later work leveraged the bases of social power to propose his "Power/Interaction Model of Interpersonal Influence" (1992). This theory examines motivation, power strategy, feedback, and adjustments to influence techniques in systematic way, rooted in social psychology (Raven, 2008).[2]

Here, a note about the vocabulary of dyadic social influence is in order. Social Power Theory explores how 'Agents' influence 'Targets'. This relationship is often described in limited hierarchal terms, such as leader / follower or supervisor / subordinate. While Agents / Targets

[2] While this theory may provide insight into developmental aspects of leadership, its depth and complexity are well outside the limits this paper. It is even possibly outside the limits of the engineering leadership field itself (at this time), as a far more robust and complex understanding of engineering leadership practices would be needed to apply this theory.

are often associated with positions or titles, this association is not prescriptive, even if it is often accurate. However, such a reductionist interpretation of dyadic social influence ignores the very nature of social influences. In fact, social influence can be dynamic: the morning's Agent is the afternoon's Target. It can be negotiated: multiple team members may claim privileged information or expertise. And it can be dependent on context: the technical expert Agent is the project manager's Target. In other words, by not attaching the relationship to position or socially acknowledged status, the full dynamics of social power can be explored.

In addition, by choosing to adopt the vocabulary of social power, robust discussion about power, leadership, and influence is facilitated. For example, one can focus on actual influence between individuals, which can be specific and concrete (rather than resorting to impersonal power fields). Or, one can foreground the role of identity and agency as important factors in wielding personal influence. Finally, one is able to focus on social interactions within the peculiar values, behaviors, and expectations of the engineering profession. This paper will adopt French and Raven's vocabulary of 'Agents' influencing 'Targets'

The Bases of Social Power theory describes six essential ways that humans exert influence on one another: Legitimate, Expert, Referent, Informational, Reward, and Coercive Powers (Raven, 1964).[3] The theory is based on Lewin's work in interpersonal dynamics. It suggests that in all social contexts, humans influence one another for various reasons: e.g., join in common cause, conflict in objectives, sharing resources.

French and Raven found that power, which they defined as the potential for exercising influence, could be characterized by three features: social dependence, (meaning that there must be engagement between the Agent and the Target), supervision (the ability of the Agent to observe compliance by the Target), and endurance (how long the effect lasts). Later, French and Raven extended Social Power theory to explore interpersonal dynamics; Due to the complexity of this topic, this paper will only address interpersonal dynamics in a limited way where necessary.

The six Bases of Social Power can be summarized as follows:

1. Legitimate Power— generally derived from a leader's position or role in an organization. This power relies on socially accepted power dynamics, which can lead to several pathways for this power to act, such as authorized position or perceived responsibility. Surveillance is unimportant, and it lasts as long as long as legitimacy continues. This power is further differentiated based on the source of legitimacy: Position, Reciprocity ("I did that for you, so you should feel obliged to do this for me"), Equity ("I have put in the hard work, so you need to put in your fair share"), and Dependence ("I need your help to get the task done") (Raven, 1993, pp. 234-235).
2. Expert Power—generally derived from a leader's specialized knowledge or expertise in a particular field (such as engineering). As with Legitimate Power, it is socially dependent. However, it has a very limited scope, as the Target must acknowledge the Agent's superior understanding or experience or expertise on the topic at hand.

[3] The careful reader will note that the original theory outlined only five bases of power. 'Informational power' was subsequently added by Raven, leading to some confusion: most modern authors acknowledge six bases, but many recognize five (see Raven, 1993, pp. 231-232 for a fuller discussion of this change).

3. Informational Power—generally derived from an Agent's deep understanding of complex challenges. Unlike Expert Power, this power base requires the Agent to explain the causal relationships of the challenge in question. As a result, the exertion of this power dissipates and transfers it, as the Target now possesses the Informational Power on the topic in question. Hence, this is the only socially independent power base, as the Target adjusts beliefs or behaviors based on understanding of causal relationships; surveillance, obviously is unimportant.
4. Referent Power—derived from interpersonal relationships and affinity towards the Agent, possibly based on the Agent being an 'exemplar'. This does not require surveillance, and it often endures over time and across contexts.
5. Reward Power— derived from the leader's ability to provide incentives for desired behaviors, such as promotions, bonuses, or other forms of recognition. This power requires surveillance to enforce, and it is a 'harsh' power (meaning that it constrains individuals' freedom).
6. Coercive Power— derived from the ability to punish or sanction others, such as through demotions, reprimands, or other penalties. Like Reward Power, it requires surveillance and is a 'harsh' power (Pierro et al., 2013, p. 1124)

Because domains and boundaries of social power are important to the theory itself-- and especially relevant in this current research-- the paper will adopt vocabulary highlighting these boundaries. In particular, to highlight the close relationship between the scope of one's responsibility (be it technical or organizational) and the power one wields, references to either will be denoted by the term 'power-responsibility'. This concept is especially important when discussing the burden of responsibility that decision-makers bear, as well as the responsibility to be technically competent that is expected of professional engineers.

In summary, Social Power theory provides a robust, comprehensive model of interpersonal influence, or leadership. While many leadership theories (e.g., transformational leadership, servant leadership) outline specific ways influence is operationalized (or should be operationalized), this theory establishes the underlying forces that shape leadership practices (Pierro et al., 2013).

Technical Mastery

The first, (and most common) of the three orientation is Technical Mastery, where an engineer leads by "…[sharing] their well-developed technical problem-solving skills with others through informal mentorship" (Rottmann et al., 2015, p. 7). Through mentorship, power-responsibility is wielded through four primary power pathways according to Social Power Theory: Legitimate (Position) Power, Expert Power, Informational Power, and Referent Power. Firstly, Legitimate (Position) Power is exercised when a supervisor is training or overseeing a subordinate. In engineering, this may be relevant when an Engineer-In-Training (EIT) works for a Professional Engineer (PE), during the years before an engineer earns a Professional Engineering license. In this circumstance, the PE in charge is fully responsible for their work, including work that is completed by the EIT; the EIT's work is fully subject to the PE review and critique. In addition, it is possible that the large power differential existing for new employees facilitates the use of harsh power bases: "…coercion, reward, legitimacy of position, equity, and reciprocity" (Pierro et al., 2013, p. 1124). These bases exist because the new EIT has yet to demonstrate competence

Social Power	Agent – Target Relationship (Technical Mastery)
Legitimate Power	Supervisor to subordinate. PE to EIT
Expert Power	Technical expert to non-technical client. Technical master to novice. Informal mentor to mentee.
Informational Power	Technical master to novice; Informal mentor to mentee (with background and reasoning)
Referent Power	Highly respected technical expert to novice / junior engineers.

Table 1 – Technical Mastery Bases of Power

and skills needed to enjoy more autonomy.[4] As the employee demonstrates competence, more autonomy is rewarded: this shift is typically favorable to the EIT and "… associated with more positive individual and organizational outcomes" (Pierro et al., 2013, p. 1124). This process shields the EIT from bearing responsibility for which they are not yet prepared, and it ensures the organization is providing competent services.

Secondly, within the Technical Mastery Orientation, Expert Power is exercised when an Agent critiques or corrects a novice's technical work; they may also provide creative solutions, based on broad experience in similar challenges. In addition, Expert Power is exercised when these leaders "…explain complex technical concepts to clients with non-engineering backgrounds" (Rottmann et al., 2015, p. 9). While efficient, this power only endures when the Agent is firmly in her area of expertise, and the Target still lacks required relevant technical skills or organizational knowledge. Importantly, this is distinguished from Informational Power because the Agent does not give adequate causal explanation, hence the Target is ill-equipped to bear responsibility going forward, as they do not understand the reasoning behind the Agent's direction. Of course, as noted previously, this dyadic relationship is fundamental to the PE licensure process.

Thirdly, Informational Power is exercised when the Agent elucidates fundamentals of a complex process, proven pathways to solve challenges, or nonobvious reasoning for existing solutions. This Informational Power is really a partial transfer of power when exercised, as the Target can now begin to understand necessary causal influences, so he is equipped to bear responsibility in that challenge. Through use, it can lead to the incremental transfer of this power through knowledge accrual that is essential to a novice engineer bearing increased responsibility; this process is also essential for large organizations to maintain and develop institutional knowledge. In terms of social power, this is because Informational Power transfer results in "Socially Independent Change"; this means that the Target permanently changes thinking and/or behavior to conform with the Informational Power (Raven, 2008, p. 2). As a result, the Target does not necessarily associate the change with the Agent, as they internalize causal influences. Finally,

[4] Lave and Wenger's Community of Practice (COP) model (Wenger, 1998a) provides extensive discussion on the process of novices moving into more central roles in technical fields (Li et al., 2009), especially in terms of motivation and identity. Additionally, the theory has been expanded to address development and education (Wenger, 1998b), cultivating COPs (Wenger, McDermott, & Snyder, 2002), and cognitive apprenticeship (Dennen & Burner, 2008). It has even been used previously to explore engineering leadership literature (Rottmann et al., 2018). However, the dynamics of this transition from novice to expert is outside the scope of this paper.

because Informational Power has been transferred, the Target may become an Agent to more novice employees as time passes.

Exercise of power bases within a dyadic relationship may also have long-term effects. Because the scope of Informational Power is usually limited, it is likely that the Target will need further insights from the Agent. This may be especially true in highly complex fields or complex projects, where causal influences be non-obvious. As a result, the Agent may actually accrue Informational Power as the Target becomes increasingly aware of the depth of the Agent's expertise, despite the fact that power is transferred from the Agent during interactions. Moreover, if the exercise of Informational Power is done effectively, the Target will grow in their own technical expertise. Hence, if this exchange is sufficiently extended, it can also empower the Agent with additional Referent Power (as the Target develops an affinity towards the Agent), Legitimate Reciprocity Power (as the Target appreciates the support the Agent has given them), and personal Reward Power (as the Target appreciates the Agent's support). In an engineering context, the Agent may also accrue Legitimate Power of Reciprocity, if the Target has benefitted from the Agent's training or support. "They helped me when I needed it, so now I help them when I can." While worth acknowledging, these long-term effects of exercising power in dyadic relationships are complex, and they fall outside the scope of this research[5].

TECHNICAL MASTERY ORIENTATION	
Social Power	**Key Mechanisms**
Legitimate Power	Those with more senior tenure or technical expertise guide / influence others with less socially-recognized authority
Expert Power	A technical expert instructs / influences non-technical or novice engineers, based on extensive technical expertise.
Informational Power	Technical master explains / instructs junior engineer; Informal mentorship on both technical and organizational processes.
Referent Power	Recognized and respected technical expert exemplifies professional values, with less-senior team members complying with Agent suggestions / insights..

Table 2 – Technical Mastery Key Mechanisms

Fourthly, Referent Power may be enjoyed by the Technical Master. Referent Power comes from a Target "...seeing the Agent as a model…" worth emulating (Raven, 2008, p. 3). An important aspect of the Technical Mastery Orientation is excellence in technical problem solving. By exercising this important engineering value, the Agent "… inspire[es] colleagues to set high standards for technical problem solving" (Rottmann et al., 2015, p. 8). One characteristic of Referent Power is that it does not depend on observation; in other words, the inspired engineer will continue to be influenced by the Agent's influence, even when there is no interaction between them. In addition, the amount of power is proportional to the attraction from the Target to the Agent. Hence, Technical Masters may enjoy exceptionally high Referent Power when

[5] Raven subsequently extended the 'Bases of Social Power' theory to more fully understand and explain the interpersonal influence process. This research led to his 'Power/Interaction Model of Interpersonal Influence', which explored (among other things) motivation for exercising power, adopting power strategies, and the long-term impact of exercising power (some of which are mentioned here) (see Raven, 1992, 1993; Raven, 2008).

they typify engineering values across multiple fronts, selflessly support organizational projects, or actively mentor novice and junior engineers. Relevantly, Referent Power is most closely associated with identity, as it is rooted in a Target's desire "…to be like…" an Agent, or an attractive Agentic group (French & Raven, 1959, pp. 161-163). Finally, it should be noted that Referent Power usually applies only within particular contexts; however this boundary can be permeable, leading to the Agent being able to influence the Target in non-technical fields (e.g., organizational dynamics).

A final note pertains to early-stage engineers. Here, harsh powers (i.e., Coercion and Reward) may play a part in influencing behaviors, as does Legitimate Positional Power. This is largely due to their untested competence, and likely due to their lack of relevant expertise and experience. As a result, they operate in a less-autonomous space, until they have proven their ability to bear power-responsibility; first in small ways, then in larger ways, as their competence grows.

Collaborative Optimization

The second of Rottmann et al.'s Three Orientations is Collaborative Optimization, where an individual leads "….effective and efficient teams across organizational units by learning about and leveraging their colleagues' strengths" (2015, p. 7). Under this Orientation (which was the most common of the three), social power-responsibility for the Agent is primarily wielded using Legitimate, Informational, and Referent Power.

When a project leader is authorized with oversight of the project and delivering a final product, they enjoy Legitimate (Positional) Power. Targets, even if peers to the leader in all other ways, are subject to the project leader (within the bounds of the project) via positional legitimacy. Of course, subordinates in this environment are included because they have Technical Power, which is required for project success. In this capacity, they have responsibility to the group, to the project, and to the organization itself to provide sound technical guidance. Part of the project leader's success is "…bringing out the best in everyone," which includes elements of trust in, and respect for, team member's technical competence (Rottmann et al., 2015, p. 10). From Social Power Theory, this empowers team members to exercise Expert Power to influence project direction to accomplish team goals. Related, the boundaries of Expert Power limit the

power-responsibility that team members have in the overall project. Beyond the boundaries of individual expertise, project leaders bear the ultimate power-responsibility for the success of the project: hence their role as decision-makers. This has the potential for conflict, as project leader Legitimate Power may influence in a different direction than a team member's Expert Power. If so, the nature of power dynamics is such that the party exercising influence most forcefully will

Social Power	**Agent – Target Relationship (Collaborative Optimization)**
Legitimate Power	Project manager to team member. Expert in field to project manager / team.
Informational Power	Experienced project manager to team.
Referent Power	Model / experienced engineer to novice / junior engineer.

Table 3 – Collaborative Optimization Bases of Power

prevail. That said, as mentioned previously, interpersonal social dynamics fall outside the scope of this paper.

In addition, it is entirely likely that the project leader enjoys Legitimate Power of Responsibility, where team members perceive an obligation to contribute to project success because the project leader cannot accomplish the task on her own. This is a likely scenario, as the nature of large or complex engineering projects demand expertise from multiple fields, leaving it highly unlikely that any one individual can navigate a project without support. Moreover, the very nature of building a cross-disciplinary team is motivated by the need to collect deep expertise across multiple fields. The measure of team members' commitment to project success (as service professionals), combined with how essential they are to project success, determines the strength of this power.

One common practice worth addressing here is the transfer of Legitimate (Position) Power; One individual may be given positional authority for one phase of a project, with positional authority transferring to a different individual for a subsequent phase. This practice highlights the boundaries that Legitimate Power has in the Collaborative Optimization Orientation; it need not be one individual that enjoys Legitimate Power over peer Targets in all situations. Rather, one may enjoy Legitimate Power over another for the first stage of a project; but for the second stage, the former 'leader' is now subject to Legitimate Power of a former 'subordinate'. Or the 'leader' may enjoy Legitimate Power over another peer in a morning project, then be subject to Legitimate Power of the other peer in a different afternoon project. Regardless, Legitimate Power in the Collaborative Optimization Orientation need not be equated with something as simplistic as the traditional leader-follower relationship (i.e., "Great man"), even if it shares some characteristics, albeit in limited scope.

It should be noted that if a project leader has adequate Legitimate (Position) Power, it is entirely possible that she also exercises Reward and Coercive Power through bonuses and sanctions, respectively. While less common in engineering leadership discussions, these 'hard powers' are still an important component of the engineering profession, as organizations strive to influence employee performance. In engineering, these are less important in themselves, but they can be pathways to accruing (or losing) other power bases: Does the Agent empower subordinates to achieve? Does she reward excellent performance? Does she reward based on personal favoritism? Are sanctions unduly harsh or inappropriate? Answers to each of these questions impact the recognition of the Agent's example of engineering ideals. And this recognition will elevate or diminish the Agent's Referent Power in the community.

While project leaders are often authorized with oversight, it is not uncommon for a team to address a project without an authorized 'leader'. These self-organizing teams arise out of a recognized problem that engineers (or external decision makers) identify as important. The motive behind these teams was captured succinctly in Rottmann et al.'s work: "When there is a problem and something goes wrong, everyone steps up and says, 'how can we help to fix it?' That happens all of the time here. It's never a case of, 'that's not my problem.'" (Rottmann, p. 10). In this situation (the absence of Legitimate Position Power), the

Collaborative Optimizer that emerges must rely on other forms of social power, such as Informational and Referent Power, to influence project direction and decisions.

The second form of power that leaders in a Collaborative Optimization Orientation exercise is that of Informational Power. Because those team leaders are often chosen due to their experience in relevant projects, they may enjoy deep knowledge of the ways technical fields interact in similar projects. So, while they may not wield Informational Power in every relevant technical field (in fact, this is often the reason others are brought on the team), they may have a rich understanding of how the technical fields interact. The experience posits them in a place of power-responsibility, as the well-qualified leader likely understand a bigger picture than other technical experts on their team. On the other hand, if no casual explanations are given, it is Expert Power (about organizational processes, likely) that is being practiced.

In addition, it is worth noting that the Collaborative leader has often developed extensive technical competence, hence the trend for mid-career and senior engineers adopting this Orientation. This characteristic of Collaborative Agents has three advantages. First, they will likely contribute to one technical aspect of a cross-disciplinary project, making them a valued part of the team. Second, previous competence cultivates a respect for the role of technical competence, empowering the leader to appropriately leverage the technical expertise of those on the team. In other words, the leader is comfortable with other team members exercising power-responsibility within their technical domain, while still maintaining power-responsibility of the project overall. Third and finally, technical competence is important in the engineering profession as a currency of recognition and respect (Wenger, 1998a). This currency smooths resistance to Expert Power, as team members recognize that the leader has demonstrated competence in their previous technical roles.

The third form of power that Collaborative leaders exercise is Referent Power. This basis of power is often characterized as charisma and widely ridiculed by engineers, as it depends on Target affinity for the Agent: "… standing on top of a hill, waving the flag, sitting on your horse with the peasants behind you carrying their [pitch] forks is the exact opposite of anything I personally or anyone I know wants to do" (Rottmann et al., 2015, p. 6). However, Referent Power can be understood in more nuanced form. Referent Power exists when a Target admires or trusts an Agent enough to comply with her wishes, which can happen in several ways. Here, the Agent is an exemplar of the model engineer: maybe they've issued several patents (demonstrating technical and creative excellence), maybe they've provided essential technical insights, maybe they've proven their ability to navigate interdisciplinary projects effectively, or maybe they persistently demonstrate deep knowledge across a wide range of topics. In other words, the leader exemplifies the best of us. The issue here is not whether Targets feel affinity and loyalty towards an Agent; rather, the issue is the values that reflect the 'best of us.' In other words, the emotional frenzy an Agent has over a mob is power. And, the measured trust and loyalty to a senior engineer based on years of service and competence is a similar power, but emanating from a different locus of awareness. The difference is in the values that imbue the Agent with Power: are engineers 'charismatic visionaries' or 'applied scientists'? Are they 'the top of hierarchy' or 'service professional[s]' (Rottmann et al., 2015, p. 7)? Either way, Referent Power is in action.

COLLABORATIVE OPTIMIZATION ORIENTATION	
Social Power	**Key Mechanisms**
Legitimate Power	Formal project leader guiding a team; Technical expert (non-project leader) influencing project team decision-making in relevant field.
Informational Power	Experienced project leader informing / instructing relevant organizational processes that impact project decisions.
Referent Power	Model / experienced engineer influences group decisions based on reputation of previous success, especially as an archetypical service professional (i.e., modeling the 'best of us').

Table 4 – Collaborative Optimization Key Mechanisms

It should be noted that the Collaborative leader who exploits her relationship with others for personal gain (or through personal favoritism) will quickly lose her Referent Power, as she no longer exemplifies the best of us-- as rational, task-oriented service professionals and Agents of the organization. The second way the leader accrues commitment is through good interpersonal skills; Referent Power may be based on the ease and satisfaction with which followers participate in group efforts. In other words, other peer-experts simply enjoy working with this leader, likely because it provides an environment where they can perform at their best. Here, charisma does have an influence, but it is not of the 'torches and pitchforks' variety. Rather, an Agent, through interpersonal skills that are consistent with engineering values, is able to both gather an effective team (e.g., facilitating interdependence, optimizing team process, leveraging strengths) and cultivate an environment within which everyone can be at their best (e.g., motivating and enabling, managing conflict).

Finally, the Collaborative leader may also leverage Expert Power, due to her ability to effectively navigate organizational challenges and barriers. This ability may be distal enough from the technical side of engineering that Targets conform to an Agent's direction based on the foreign nature of organizational theory, marketing, or a legal department. In fact, the emergent leader is likely to enjoy this power, as expertise in working across organizational units (which may not be all technical) or exhibiting organizational savvy are some essential components of the Collaborative Optimizer (Rottmann et al., 2015, p. 10).

Organizational Innovation

The final Orientation of engineering leadership is Organizational Innovation, where leaders "…used entrepreneurial thinking to bring technically and scientifically sound ideas to practice and to market" (Rottmann et al., 2015, p. 15). This leader Orientation has the broadest scope, as the power-responsibility of the leader spans from the conception of a project to its final execution. This broad scope requires insight into customer needs and broad awareness of organization technology and resources, which is likely why most Organizational Innovators are C-Suite and senior engineers. In contrast with the Collaborative Optimizer and Technical Master, the Organizational Innovator selects or envisions a project, rather than simply executing a project that has been identified or assigned. It is also possible that this leader supports continued development and products based on an initial breakthrough or technology. More so than the other two Orientations, the Organizational Innovator also must successfully navigate interface with non-technical departments to bring products to market.

Social Power	**Agent – Target Relationship (Organizational Innovation)**
Legitimate Power	Experienced senior / high-level engineer to less-experienced non-technical peer.
Expert Power	Technical expert to non-technical peers or clients.
Informational Power	Compelling, rational engineer to non-technical peer decision makers.
Referent Power	Recognized technical expert to non-technical decision makers.

Table 5 – Organizational Innovation Bases of Power

Because this leadership includes components that are exercised outward-facing-- likely towards non-engineers as the Agent influences marketing and strategic decisions-- social power dynamics differ from an engineering-only context. Here, the distinction between '*how to lead engineers'* (most applicable for the other two Orientations) and *'how engineers lead'* is particularly relevant. Specifically, the Agent likely does not enjoy any 'harsh' bases, as Targets are likely at the same level in the organization. That said, the Agent may enjoy limited Legitimate Power, based on previous experiences. For example, if the Agent has supported previous Target initiatives, they may leverage Legitimate (Reciprocity) Power (i.e., "You owe me one.") Similarly, if the Target has injured the Agent in some acknowledged way, the Agent may exert Legitimate (Equity) Power. And the Agent may 'call in a favor' based on a need to see the Project meet success: this would leverage Legitimate (Responsibility) Power. Finally, the Organizational Innovator may enjoy some measure of Legitimate (Positional) Power, as the expertise, experience, and organizational awareness required to act as a leader of this Orientation are such important characteristics that this person has likely been promoted to a position of substantial responsibility (often to C-Suite or Technical Director). Through this power, they can directly influence other decision-makers in the organization that might support the project in question (e.g., marketing or finance).

More likely, the Agent must rely on 'soft' bases: Expert, Reference, and Informational. Expert power is enjoyed because the Agent holds comparatively vast technical expertise essential to product development and implementation. Through Expert Power, the Agent can influence Targets within the scope of technical decisions. Because the project is likely technology-centered, this Expert Power may be central to organization decisions, potentially foregrounding the Organizational Innovator in the decision-making process. That said, while within the scope of technical solutions, this Expert Power is strong; yet outside the scope, its strength drops off quickly.

The Agent may hold Expert Power in additional fields to engineering, such as finance or organizational history. In general, given the more senior demographic of these leaders, it would not be surprising for them to have developed broader skillsets, outside of engineering, e.g., "market savvy" (Rottmann et al., 2015, p. 11). As with Expert Technical Power, this power is only relevant in the respective field, so the number of Targets is likely limited.

Another soft power is Informational Power, where the Agent can clearly elucidate a compelling case for why the project should move forward, and how others can support its progress. Informational Power can be influential with any Targets outside fields of expertise of the Agent (Raven, 2008), highlighting the importance of a well-informed and well-grounded argument for the Project. This ability to intelligently navigate non-technical fields is essential for persuading others to follow, catalyzing change, and big picture thinking. It is likely unnecessary to leverage Informational Power in the technical field, as Expert Power is likely adequate, due to the Agent enjoying recognized expertise in technical fields.

The final soft power is Referent Power, where an Agent is favored by potential Targets. Here, the history leading up to this interaction is important. This favor can be developed over time through several behaviors: for example, the Agent has demonstrated commitment to the organizational mission, success in previous Projects, or dynamic favorable interpersonal engagement. In each of these cases, the Targets likely feel a personal or profession affinity towards the Agent because the Agent is an exemplar of a valuable member of the organization. As in previous analysis, the dynamics of interpersonal influence in such a complex context are beyond the scope of this paper.[6] Nonetheless, it is important that the Organizational Innovator navigate non-engineering spaces adequately, even if not exceptionally. This is because these powers can be negative; in other words, Referent Power can negatively impact other Power bases if the Agent is not an exemplar. This highlights the need for the Organizational Innovator to appreciate and navigate divergent value sets such as one might find in a large organization.[7]

ORGANIZATIONAL INNOVATION ORIENTATION	
Social Power	**Key Mechanisms**
Legitimate Power	Experienced senior / high-level engineer enjoys position of authority, likely due to tenure, expertise, and organizational knowledge.
Expert Power	Experienced senior / high-level engineer enjoy recognition of technical knowledge-power-responsibility, especially regarding priority of technical variables in decisions.
Informational Power	Accomplished engineer able to relay merits of technical solutions to non-technical audience (e.g., clients, marketing peers, HR)
Referent Power	Recognized / experienced / charismatic technical expert influences non-technical project partners towards shared objective; Targets comply willingly to exemplar.

Table 6 – Organizational Innovation Key Mechanisms

[6] Full discussion of social power engagement in this situation demands integration of the 'power-interaction model of interpersonal influence. (Raven, 1992). This addresses, amongst other things, the motivation of the Agent to influence, choice and implementation of the strategy of power, and strategy adjustment based on effectiveness. (Raven, Journeys, p. 182)

[7] This ability to navigate multiple contexts is essential for leadership success in positions of higher responsibility. The Competing Values Framework (CVF) is based on this finding, and it provides a theoretical guide for classifying common types of contexts (see Quinn, 1984; Quinn, 1988; Quinn & Rohrbaugh, 1981, 1983). An example of this difficulty is research that suggests leaders motivated by effective task execution are far less likely to effectively navigate complex scenarios, such as organizational or interpersonal power dynamics (David Winter, 1973).

Furthering Engineering Leadership Identity with Bases of Power

This adaptation of the Three Orientations of Engineering Leadership Identity, using Social Power Theory has provided a conceptual perspective on engineering leadership that leverages social power as an explanatory mechanism of the leadership that engineers acknowledge in their profession. Several themes from this integration of theories emerge.

Technical competence lies at the center of engineering values and engineering leadership. It is more than a "skill"; it is the fundamental currency of credibility. For engineer-Targets, this fundamental currency frames their perception of all power bases. Expert Power depends on perception of Agent mastery. Informational Power depends on perception of Agent understanding of causal influences (primarily technically). And, Reference Power depends on Target appreciation of the Agent as an exemplar of technical competence. Likewise, for non-engineer-Targets, the Expert, Informational, and Reference Power depend on perception of technical competence, as it is central to successful development and implementation of technical projects.

Another value core to engineer-Targets recognition of power is rationality, based on previous experience or broad knowledge. This value is especially important to engineering due to the autonomous nature of the profession, where harsh power bases have limited effectiveness (Pierro et al., 2013). As a result, rationality guides engineer perceptions outside of technical fields, as they bear responsibility for decisions. It is through this rationality that the Technical Master explains causal connections to the junior engineer or project peer. It is through this rationality that the Collaborative Optimizer can explain reasoning for decisions, either based in organizational processes or based in interdisciplinary integration. Likewise, trust is given that Expert Power is not a front for personal interests or specious understanding but grounded in real experience and competence. The Organizational Innovator leverages rationality through recognized non-technical competencies: "…thinking outside the box, realizing a vision, institutionalizing best practices…" Their "…broader picture of what is going on…" facilitates trust from engineer peers (Rottmann et al., 2015, p. 11). And their recognized technical competence and their rationality empower them to persuade their non-engineer peers.

A third theme is the importance of engineering values (e.g., technical competence and rationality) to the perception of leadership. To engineers, (simplistic, "great man") leadership characteristics appear anathema to engineering priorities. In fact, the tension between engineering values and (perceived) leadership characteristics were a primary source of resistance to engaging with leadership (Rottmann et al., 2015). Social Power Theory illuminates this tension by recognizing Reference Power emerges when Targets identify with, or feel affinity towards, an exemplar Agent. Importantly, community values play a central role in the values that are elevated and those that are disparaged. Hence, an Agent may enjoy large Reference Power in one community (e.g., change agent), while being penalized with negative Reference Power in another community (e.g., process optimizer). For engineers, technical competence and rationality form two central pillars of this value set, differentiating them from their non-engineering peers. This means the values by which Reference Power is judged are peculiar to engineering, however the nature of the power base itself spans human interactions in all communities.

Implications and Conclusions

Parsing out this theory empowers later-stage engineers to clarify vision and act courageously to influence the world around them. Not because they want to lead, but because they believe, as applied scientists, that competent execution of their work is essential to serving the organization and the public welfare. In other words, as a service professional, the public / company rely on your technical competence. The competent professional exercises influence to ensure that tasks are capably accomplished: this highlights the message that 'what you do matters.'

Additionally, training late-stage engineers on the bases of power provides an informed understanding of ways to influence those around them. By choosing to not problematize leadership (by propagating simplistic individualistic models), engineers can gain a more nuanced perspective both on how humans conduct themselves in groups, and in the ways engineers differ from other groups. By clarifying these dynamics, engineering leaders are better equipped to clarify where they bear power-responsibility, to understand how influence is wielded (for the benefit of the project or organization), and to act courageously to influence those around them to a technically sound and rational future.

In summary, social power theory provides insights into the mechanisms by which engineers exercise influence over one another and over adjacent non-technical groups. By parsing out how these mechanisms operate, a more nuanced understanding of how engineers lead has been put forward. In addition, this paper suggests that this perspective has developmental value, especially as mid-career and senior engineers strive to more effectively achieve goals far beyond what one person can accomplish.

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