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# Engineers as business leaders: A need to investigate formative collegiate experiences of highly successful executive-level engineers

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## 1 Introduction

The engineering and construction (E&C) industry is human resource-intensive. Most E&C tasks are performed, handled, or supervised by humans. Besides, the size and complexity of today's E&C projects require the involvement of many professionals, often from different organizations, working together (Ballesteros-Pérez et al., 2019). Further, the E&C industry is not only human resource-intensive but also leader-driven. The most vital resource of an E&C firm is its executive leadership (Perrenoud and Sullivan, 2017). Of course, leadership is multifaceted and must be defined and bounded within the context of the topic of interest (Schell et al., 2018) — highly successful executive-level engineers leading project-based E&C organizations.

The E&C industry delivers capital projects for other sectors, including transportation, water treatment, energy, manufacturing, communications, commercial, and petrochemical, to list a few. Generally, many delivered projects are considered by governments as critical infrastructure systems; thus, the robustness of the E&C industry is crucial for designing, building, maintaining, and operating such critical infrastructure systems. Therefore, engineering programs in higher education need to ensure a robust pipeline of competent engineers capable of leading the E&C industry in the coming days. Unfortunately, however, literature is scarce regarding formative collegiate education experienced by highly successful executive-level engineers in the E&C industry.

In healthcare, for instance, based on responses from 181

Johns Hopkins Medical School students, it was reported that specific formative experiences had crucial impacts on graduating medical school students. Thus, it can be argued that a better understanding of the diversity and range of formative experiences experienced by medical students would more effectively prepare educators to guide students' personal and professional growth. Some of the high impact formative experiences during medical school include (Murinson et al., 2010):

- Encountering an exceptional role model in medicine;
- Discovering an area of medicine that seems perfect for you;
- Seeing a patient whose life was saved by medical intervention;
- Having a really bad clinical experience; and
- Seeing a patient die.

The overall research space of what makes leaders effective or how did leaders become leaders has many different angles, from the engineering literature, education, management, and beyond. Among leaders, in industrial settings, chief executive officers (CEOs) hold the topmost decision-making authority in and for their respective organizations. Some may implicitly assume that top managers are homogeneous, selfless, and perfectly substitutable and do not matter for a firm's operations. However, CEOs and other top managers are vital factors determining corporate practices; according to prior research, who the CEO was mattered when deciding a firm's investment, financing, and different organizational strategies (Bertrand and Schoar, 2003).

Therefore, it is understandable that CEOs have been studied from various perspectives, given such power, responsibility, and importance in their respective organizations. For example, there has been a debate regarding whether bringing in an outsider CEO would benefit a firm's performance (Georgakakis and Ruigrok, 2017). In China, corporations headed by politically affiliated CEOs had a significantly higher probability of donation and cash

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giving in response to government demands for corporate contributions (Jia and Zhang, 2013). Again, in the Chinese context, CEOs' subjective view of time—time urgency and pacing style—shaped firms' innovation, corporate venturing, and strategic renewal activities (Chen and Nadkarni, 2017). Even the face of success, in a literal sense, was investigated: A CEO's facial appearance was rated more competent than a non-CEO's, and the facial appearance of CEOs from large firms was rated more capable than that from smaller firms (Graham et al., 2017). CEOs' educational backgrounds also garnered attention from the research community and the public. For example, high-profile CEOs' academic degree majors and academic institutions have been reported (Hess, 2018). However, no significant relationship was found between the type or selectivity of the CEO's alma mater and the CEO-led firm's financial performance (Gottesman and Morey, 2015). In addition, others reported how many top-level US CEOs held an advanced business degree (Williams, 2021) or a legal degree (Wecker, 2012).

### 1.1 Engineer-leaders

An engineer-leader is a leader as well as an engineer. Many engineers see the idea of leadership as something incongruent with their professional identity as an engineer. However, engineers can easily recall from their experiences influential colleagues leading in their workplaces. Such influential engineers lead others through 1) integrating easy-to-understand communication skills, high-level pattern recognition, and creative problem-solving, i.e., technical mastery, 2) building and catalyzing high performing teams by masterfully striking a balance between the humanistic and technical aspects of the profession, i.e., collaborative optimization, and 3) bringing technically and scientifically sound ideas to practice and market, resulting in new technologies, processes, patents, and jobs, i.e., organizational innovation (Rottmann et al., 2015).

Then, what kind of roles can engineering management educators play in developing technically adept engineer-leaders? Knight and Novoselich (2017) reported that engineering students' undergraduate experiences were more strongly associated with self-reported leadership skills than their demographic attributes. It was also reported that curriculum contents had the strongest relationship with engineering students' leadership abilities, suggesting that purposeful development of engineering curriculum might be an effective way to foster the development of engineer-leaders.

Similarly, based on a national dataset from the 2015 National Survey of Student Engagement in the US, Schell et al. (2018) identified the predictors of leadership outcomes among engineering college students. It was observed that having leadership experiences in coursework or course discussions and interacting with diverse people

made the most substantial impact on leadership outcomes, such as working effectively with others, understanding people of other backgrounds, and becoming a leader in life outside of college. Considering the importance of producing engineers ready to lead, engineering educators, practitioners, and government agencies should understand how effective existing engineering leadership development programs are.

The effect of the undergraduate experience is one of many convoluted factors in the formation of CEOs. Therefore, it is crucial to improve our understanding of the underlying processes and mechanisms in forming engineer-leaders so that engineering educators can help engineering graduates be prepared for leadership roles in various sectors. In addition, investigating collegiate experiences could provide valuable insight into which educational experiences the engineer-leaders consider formative and why. Potential benefits of such investigations include 1) systematically documenting formative educational experiences of engineering-based executives that can be relayed to future executives, 2) identifying skills and attributes necessary to propel engineering graduates to executive-level managers eventually, 3) placing the groundwork for enhanced E&C sector-specific teaching and learning framework to support the development of post-secondary students in the area of engineering management, and 4) serving the basis for future long-term follow-up research on how graduates are benefited from the enhanced education and training.

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## 2 Pilot study

The authors examined the CEOs leading *Engineering News-Record* 2021 Top 400 Contractors ("ENR 400 CEOs" hereafter) as a pilot study to see their undergraduate institutions. Prior research has pointed out a lack of significant relationship between programs and engineering students' self-reported leadership abilities (Knight and Novoselich, 2017). However, the pilot study provided exciting statistics. 276 ENR 400 CEOs' respective undergraduate institutions were identified—160 institutions produced at least one ENR 400 CEO. Of the 160 institutions, a mere 6 institutions collectively granted degrees to more than 35% of the examined ENR 400 CEOs (see Table 1).

Granted, these are relatively large institutions enrollment-wise; however, many similarly-sized institutions did not land on this list. Why were some institutions more productive in producing future E&C top executives than others? Are there any institutional and curricular factors that contributed to this outcome? Have these six programs emphasized certain aspects in their training that positively prepared their students for more successful leadership roles? Further research is needed to understand what the statistics mean. Had any formative educational experiences

**Table 1** Six institutions that granted most undergraduate degrees to the examined ENR 400 CEOs as of September 2021

| No. | Institution   | Number of CEO-alumni |
|-----|---|----------------------|
| 1   | Texas A&M University                                | 14                   |
| 2   | Purdue University                                   | 13                   |
| 3   | Auburn University                                   | 9                    |
| 4   | University of Florida                               | 8                    |
| 5   | Virginia Polytechnic Institute and State University | 7                    |
| 6   | Kansas State University                             | 6                    |

influenced the development of their outlooks, perspectives, and ways of thinking, knowing, and doing? Are there critical institutional success factors that other post-secondary institutions can adopt to develop future executive-level managers better suited for project-based organizations in the E&C industry?

### 3 Possible research directions

#### 3.1 Understand formative collegiate educational experiences of highly successful engineer-leaders

Effective and successful leaders do have trait-like qualities and attributes that are not generally possessed by non-leaders. Leaders' attributes play a more substantial role in predicting success as leadership situations become more complex and varied. Leader attributes include cognitive abilities, personality, motivation, social appraisal, interpersonal skills, leadership expertise, and tacit knowledge (Zaccaro et al., 2004). While some leader attributes are not likely to be as malleable, other leader attributes such as leadership skills and expertise can be altered substantially through maturation, experience, and targeted training interventions. Further, cognitive and motivational attributes such as metacognitive skills, self-regulation skills, mastery motives, and learning goal orientation may influence how much knowledge and information a leader derives from their experience (Zaccaro, 2007). Besides, engineering students' leadership skills could increase throughout their undergraduate experiences, whereas their pre-college experiences may be insignificant (Knight and Novoselich, 2017). What matters in leaders' formative experiences is the meaning leaders make of the experience, not the experience in and of itself. After going through the same event, two similarly positioned leaders may draw different meanings from that experience (Janson, 2008). In this light, the authors suggest investigating what educational experiences are remembered, processed, and extracted as formative for their successes by highly successful engineer-leaders leading engineering-oriented organizations. A comparison of characteristics between engineer-leaders and leaders without an engineering

background could be studied as well.

#### 3.2 Identify critical institutional success factors in training engineering students to be a future leadership-level workforce

Experiences that impact leaders, resulting in learning relevant to their leadership, are called leadership formative experiences. Most major learning and developmental psychological process theories place experience at the center of the learning process. For instance, in the learning theories based on the law of effect, behavior is guided by past results; behaviors that are not rewarded are likely to appear less and less. Likewise, components of self-efficacy develop based on experience. Leaders' testimonies too often reveal that personal experience was an essential element in their learning of leadership. Therefore, leaders' formative experiences play a crucial role in shaping and reinforcing leaders' identities. However, there may be a significant time lag between the formative experience and the recognition of its importance (Janson, 2008). Whether in family life, school life, or social life, successful experiences in leadership roles show the person that others perceive them as a leader. Such experience-based knowledge of leadership becomes inseparable from the development of the person's self-concept as a leader. Thus, early experiences of leadership largely shape a person's leadership. Based on surveying and interviewing the Israel Defense Forces male soldiers, it has been reported that "leaders, more than non-leaders, remember themselves as experiencing more leadership roles at high school, enjoying higher social status at school, and trying more to change things in the school framework" and "that these experiences enhanced self-perception as a 'leader', strengthened their self-efficacy in the ability to influence people, and gave them knowledge about their personal leadership" (Amit et al., 2009). Therefore, it is essential to identify critical institutional success factors so that engineering college students are trained to be more likely to succeed as future decision-makers. Engineer-leaders may credit extra-curricular activities (acting, varsities, marching band, etc.) for their professional success; thus, distinctions should be made between institutions' and individuals' roles in engineer-leaders' professional success.

#### 3.3 Develop and validate strategies that prepare engineering students to be successful as decision-makers

Formative education engages the different dimensions of the whole person—intellectual, emotional, social, and spiritual—and challenges a young person to strive toward more purposeful lives. In a post-secondary educational setting, examples of formative education experience include establishing a foundation for intellectual development, getting to know academic adviser, focusing on personal development in relationships, society, academics,

spirituality, career, and professional skills, previewing upcoming long-term commitments, reflecting on the common good, directly contacting with marginalized populations, and integrating intellectual, social, and spiritual lives through various vehicles like mentorship programs, retreats, leadership opportunities, and service experiences (retrieved from [bc.edu/content/bc-web/schools/lynch-school/about/Formative-Education.html](http://bc.edu/content/bc-web/schools/lynch-school/about/Formative-Education.html)). By analyzing highly successful engineer-leaders' educational experiences, engineering educators could develop strategies that help prepare engineering college students to succeed in their professional careers at higher levels. One hypothesis on this front is that requiring undergraduate students to undertake extensive compulsory internships within the E&C industry is positively associated with students' future professional success in the E&C industry. This requirement might help the students gain real-world experiences in advance and allow them to commit to the profession or exit earlier.

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## 4 Closing

Given technical mastery, collaborative optimization, and organizational innovation that engineer-leaders have internalized, the authors are eager to see more engineer-leaders running municipalities, managing corporations, and serving in governments. This article proposes the accumulation of robust evidence to understand those at the top of large successful E&C organizations, be enlightened from their formative educational experiences, and guide intervention and innovations in training the next generations of executives within engineering degree programs. Understanding the processes of developing the most vital resource of any project-based E&C organization—executive leadership—is, in itself, critical to maintaining the E&C industry's future health and strength. Furthermore, findings from this line of research could help improve E&C sector-specific teaching and learning models for sustainable engineering management leadership development, providing inspiration and direction for the engineering management curriculum design to cultivate future engineer-leaders.

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