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Work in Progress: An Investigation of the Influence of Academic Culture on Engineering Graduates' Workforce Expectations and Subsequent Work Behaviors

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Introduction

The supply of civil engineering graduates has yet to meet the demand of civil engineering industries within the United States [1]. The Bureau of Labor Statistics predicted a 7 percent growth within the 2021-2031 decade with about 24,200 job openings available each year [2], but only an estimated 21,561 civil engineering degrees were awarded in the U.S. in 2020 [3]. Furthermore, the COVID-19 pandemic has resulted in employees quitting their jobs at higher rates than ever historically recorded [4]; this has been further observed in the civil engineering industry [5]. A research survey conducted by the Future World Vision showed that employees with less work experience (5 years or less) were most likely to resign from their positions and the civil engineering profession entirely [6].

Previous studies have examined engineering graduates' retention in their professions as subsets of individual values and circumstance. However, there is limited research analyzing the overarching organizational culture of engineering colleges that may influence the expectations and outcomes of engineering graduates in industry. Organizational culture describes the customs and values unique to an organization [7, pp. 565]. These aspects of organizations can encourage or inhibit organizational success. Schönborn found that "there [were] specific sets of attitudes, values, and artifacts that differentiate[d] successful from unsuccessful companies" [8]. This work-in-progress expands on Schönborn's findings in hypothesizing that there are specific cultural norms and values adopted by students in engineering colleges that differ from those of engineering industries, and those differences may affect if and how early career engineers successfully transition to engineering careers.

Literature Review

Dimensions of success

The organizational behavior model developed by Robbins & Judge lies on the premise that inputs at the individual, group, and organizational levels influence processes which therein influence outcomes. However, this model proposes a linear path within the levels: individual inputs influence individual processes which then influence individual outcomes. It does not consider multilevel interactions, specifically how organizational inputs can influence individual outcomes. Thus, we employ a multilevel form of this model to understand how the input of organizational culture can affect the outcome of individual success. Two characteristics of organizational culture are considered in this study: outcome orientation and team orientation. Outcome orientation refers to "the degree to which …[individuals] focus on results…rather than on the … processes used to achieve them". Team orientation refers to "the degree to which work [or required] activities are organized around teams rather than individuals" [7, pp. 64-65, 69, 565].

One aspect of understanding culture is understanding what *success* means and requires in that culture [8]. For the purposes of this study, *success* will be conceptualized along the following dimensions related to outcome- and team-orientated cultures: relationships, processes, and outcomes. Relationships are the perceived social networks or connections needed to achieve a specified goal. Processes extend from relationships, providing a framework as to how a particular task or goal is to be achieved. Finally, outcomes are the result metrics that determine whether or not a task or goal was adequately achieved [7, pp. 64-65]. These dimensions are drawn from prior literature on culture [7-11] and allow us to compare and contrast engineering colleges and the engineering workforce. We propose a theoretical model that entails these three dimensions along which school and workplace vary in order to help conceptualize how different cultures affect the school-to-work transition and early career engineers' experiences.

Success as an engineering student

Academic success has been traditionally determined by grades and used to measure students' intelligence and general competence; thus, it has been a predictor of students' future success [12]. Likewise, employers consider GPA to be a major indicator of students' overall engineering potential [13]. Consequently, engineering students may feel extended pressures to achieve and maintain high grades to secure future employment and generally ensure their career success. In a survey provided to sophomore mechanical engineering students, more than half of the students reported continual concern about maintaining and achieving desired grades while over 60% reported frequently checking their grades [14]. This exemplifies a strong outcome-oriented culture centered around grades which is further supported by the college reward systems.

Some of the most distinguished honors in the academic institution are solely based on grades, including the Dean's List, the Summa Cum Laude designation on degrees, and the invitation to join honor societies with networking opportunities. To achieve such honors, individuals are required to outperform most of their peers in assignments and exams. With this inherently competitive environment, students may focus on one type of outcome, grades, rather than the advanced understanding or application of a core concept. As Godfrey and Parker found, "the goal of [some engineering students'] learning was to pass rather than to understand" [15]. Similarly, a recent study showed how the norms of the dominant culture regarding academic achievement and competition were internalized when "Being successful or smart [was] not about learning but instead about maintaining [or improving one's] place in the hierarchy of smartness" [16].

Moreover, the fundamental engineering courses are rooted in mathematics and science which have widely-considered objective truths both institutionally and globally. With the traditional lecture format lacking interactive discussion and collaborative in-class problem solving, instructors may rely on coaching students to get the "right" answers without structuring their curricula around the development of professional skills. Engineering professionals and employers identified many engineering graduates who were "unable to employ anything other than a 'text book' solution to solve a problem … working standard problems with a standard approach" [17]. Thus, fundamental engineering coursework that centers around solving problems with a routinized approach can inhibit critical thinking capabilities. Assignments and exams that primarily test procedural knowledge (the mastery of calculations) rather than conceptual knowledge (deep theoretical understanding) can enable students to memorize how to solve problems [18]. Therefore, students

are able to achieve academic success (outcome) with lessened reliance on learning (process) or collaboration (relationship). Figure 1 depicts the focus on one metric of success (grades) to the exclusion of attention to processes and relationships that is characteristic of engineering education.

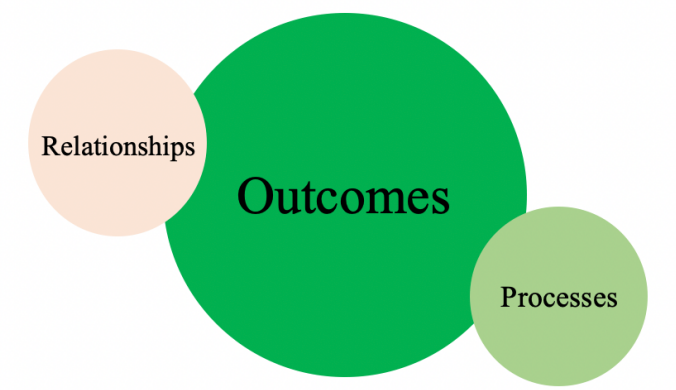

Figure 1. Disproportionate focus on one type of outcomes in school

Success as an early career engineer

Employees' work productivity is not always simple to measure, but employers may identify or acknowledge certain behaviors they believe contribute to the organizations' productivity or success [19]. In engineering, engineers are required to develop relationships and communicate with a wide range of employees from different fields, supervisors, and clients [17]. Trevelyan has described the nature of engineering work as "technical coordination" through social interactions [20-21], and this coordination necessarily relies on successful navigation of processes and relationships. Therefore, effective relationship and process skills appear to be more important to success in the workforce than they are in school. This process may be further accelerated and needed in a workplace environment with high employee turnover. As the Great Resignation has increased turnover [6], it would be of utmost importance for corporations and employees to adapt, reinforcing a culture that promotes flexibility, effective collaboration, and ultimately success built from effective working relationships and processes.

Methods

Participants and recruitment

The participants in this study were sixteen civil engineers who worked at different civil and environmental engineering firms in the eastern and midwestern United States. The participants were early career engineers who began their careers in 2017 and 2018. Their specialties spanned the major civil engineering branches, including structures, transportation/roadway, traffic, geotechnical, and waste water. The universities they attended were large, public, research-intensive universities, with the exception of two small, private universities and one large, private, research-intensive university. The universities were located in the eastern and midwestern United States. All participants had at least one internship while in college, and the majority had two. Ten identified as women and six identified as men. Ten identified as white, five identified as Latina or Hispanic (or white and Latina/Hispanic), and one identified as Arab and white.

The overarching aim of this multi-faceted project was to better understand the organizational socialization experiences of newcomer civil engineers and reasons for high attrition rates among early career civil engineers. The participants were recruited in 2017 through national and local listservs and social media postings of engineering organizations and programs, including the Society of Women Engineers, multiple American Society of Civil Engineers Younger Member Groups, and Solar Decathlon. In an effort to maximize diversity within the participant sample, recruitment help was also sought from minority-serving engineering societies, but was not obtained. Recruitment postings explained the purpose of the study and invited potential participants to contact the second author if they were interested in participating in the study. Participants received a $250 incentive the first year and it increased by $50 each subsequent year.

Data collection and analysis

This work-in-progress paper is one piece of a larger longitudinal project spanning five years. Among other topics, participants were asked about: the biggest challenges they encountered and the most important things they learned in their jobs; what early career engineers needed to be successful; advice they would give to other early career engineers; the environment of their workplaces; changes they underwent after graduation; work-life balance; and aspects of organizational socialization, including co-worker support, politics, people, performance and proficiency. The analysis at hand focuses on the questions: *What makes a successful early career civil engineer?* and *Does engineering education foster the knowledge, skills, and abilities needed for success?* For this paper, data from interviews and open-ended survey questions were analyzed using open thematic coding techniques [22] to synthesize findings from throughout the study in order identify emergent themes across the dataset. Further details about the methods and findings on other aspects of the study have previously been reported elsewhere [23-28].

Findings

As noted, participants were asked about the most important things they were learning and the biggest challenges they encountered. Examining responses to those questions revealed that processes and relationships were integral and inherent to getting outcomes– all three were needed for success. There were distinct changes in types of responses to these questions over the years. Three phases of learning and challenges were identified. The first phase spanned primarily the first year after graduation and was comprised of interdependence, technical practices, and navigating negative interpersonal interactions. For example, one participant reported: “My biggest challenge has been communicating with my manager. He has a way of always making whatever he says sound condescending. If I ever ask him a question he won't let me finish my question before speaking over me which results in him answering something I wasn't asking.” The second phase spanned primarily years two and three and was comprised of learning how to work with a wider range of people with different communication and interaction styles. The third phase spanned primarily years four and five and was comprised of transitioning into supervision and management roles. As one participant explained:

> I've learned that it takes a lot of planning to have people under you, maybe even outside of work hours…Throughout the whole day I'll be having to go and teach them how to do certain things, they have lots of questions, so it takes away from what I need to do. And I

> know they're just growing pains, but honestly sometimes I feel like I can do everything a lot quicker just by myself, but it's just part of the process. So I guess just organization and planning outside of work is something I've learned with this, and just patience and different work styles between my two employees - that's a big one too.

Another participant likewise reported that:

> My two biggest struggles would be delegating work to interns and prioritizing my own tasks. I find it challenging to assign interns work when I don't have a clear direction of what task I should give them and/or find it challenging to stop myself saying "I can do that" instead of identifying tasks they can do. Also often at busy times, it's hard to prioritize what needs to be done first.

And a third participant echoed that her biggest challenge in this phase had been "Becoming a task lead for an intern, and two junior engineers. Delegating work, answering questions, checking work while managing my own workload."

While the particular focus of each phase of learning varied, what remained constant was the salience of needing to learn how to establish, navigate, manage and overcome challenges related to new processes and relationships. This integrated relationship among processes, relationships, and outcomes is depicted in Figure 2.

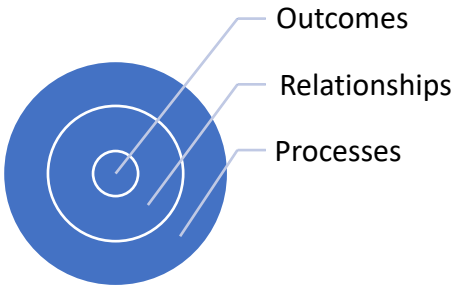

Figure 2. Integrated and equally-important dimensions of success in the workplace

Discussion

As depicted in Figure 2, outcomes in the engineering workplace were found to be inseparable from processes and relationships. In contrast, in Figure 1, outcomes in engineering colleges, particularly grades, are less dependent on processes and relationships. Upon entering the workforce, engineering graduates had to learn to establish, manage, and navigate working relationships in order to achieve their outcomes. With instructions being less clear, entry-level engineers relied on the guidance of supervisors or managers to successfully complete tasks. This provides a stark contrast to the school environment, in which there are clear instructions and approaches to completing assignments [17] and built-in systems (e.g., office hours, advising) to ensure students can successfully advance through the program.

In later years when they began to transition to management and supervisory roles, many of the participants explained that although there were tasks that would be more effectively and quickly

completed if they did them independently, their management position no longer made this feasible. As part of the organizational leadership, they needed to focus more on the processes by which tasks were completed rather than the promptness by which these tasks were completed. Therefore, it was important for them to develop positive relationships with the individuals they managed in the form of adapted management styles.

Additionally, engineering professionals were necessarily more team-oriented than engineering students, learning to adapt their working styles to cooperate with colleagues of various communication styles and successfully complete tasks. This included navigating negative interactions in phase 1 and modifying management techniques in phase 3 to ensure the tasks of individuals and department sectors alike were completed. "However, most academic situations [do not] foster teamwork". Competition among peers to achieve high grades and pursue individual interests (e.g., research, internships) [29] can create environments that are weakly team-oriented. In other words, individual outcomes in school are primarily earned by individual efforts. In contrast, our findings show that when transitioning to the workplace, engineering graduates must learn that their individual outcomes are dependent on both individual and collective efforts.

Conclusion

The school-to-work transition is difficult for many engineering graduates. Adapting to the engineering workplace requires them to alter some of the cultural norms and values they have adopted from the academic institution, most notably, outcome- and team-oriented approaches. From our findings and previous literature on the culture of engineering colleges, engineering graduates must adopt more process- and team-oriented approaches to ensure they achieve individual success and contribute to organizational success. Given that the majority of engineering graduates have only extensively been in the educational system [15], it is vital to identify approaches that allow them to better thrive in the workplace. Katz found that engineering students who had directly engaged with the professional engineering environment through interviews, co-op assignments, and seminars had "expectations [of their workplace responsibilities]…that much more closely matched the expectations of the professionals than…the students who had not" engaged with the professional world [29]. Similarly, problem-based learning through a capstone design course was shown to increase software engineering students' confidence in their technical abilities and improve their self-efficacy regarding their ability to succeed in the software engineering profession [30]. In accordance with these findings, we suggest three methods for engineering colleges to incorporate within their curriculum: 1) annual design-based or project-based courses to promote team-oriented cultural values, 2) more integration with industry professionals (guest lecturers) and practices (case studies) to gain further insight into industry perspectives [17], and 3) additional forms of feedback (peer review, draft submissions) that allow students to value lifelong learning and a more process-oriented cultural approach.

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