First Year Practicing Civil Engineers' Challenges

Kacey Beddoes
San Jose State University
Corresponding Author Email: kacey@sociologyofengineering.org

Introduction and Literature Review

The need to better prepare students for the engineering workplace is a long-standing and on-going concern among engineering educators in both Australia and the United States (Anderson et al., 2010; Cook et al., 2017; Male & King, 2014; Trevelyan, 2014). In Australia, the number of new work- and practice-based programs is growing, with the aim of addressing gaps in preparation (Cook et al., 2017; Daniel & Mann, 2018; Morgan, Lindsay, & Sevilla, 2017). Relatedly, there are concerns about high rates of attrition from engineering careers in both Australia and US (Engineers Australia, 2019; Fouad et al. 2012; Glass et al., 2013).

Identifying the first and most significant challenges recent graduates face in the workplace can contribute new insights into how students could be better prepared for the school-to-work transition, as well as reasons for attrition from engineering careers. In order to advance understandings of the transition from school-to-work, this paper presents findings from the first year of a four-year longitudinal study exploring the experiences and career trajectories of early career engineers. The specific question addressed in this paper is: *What was the biggest challenge civil engineers experienced during their first year in the workplace?*

Understanding students' transition to the workplace, and the challenges they encounter, can be approached though the lens of socialization, and organizational socialization specifically. Organizational socialization is the process of learning "the norms, procedures, and culture of a new organization" and "becoming an organizational insider who has working mastery of internal working norms, procedures, and culture of the organization" (Bauer & Erdogan, 2012, p. 97). The lens of organizational socialization focuses researchers' attention on how new employees (or newcomers) respond and adjust to their new organizations and to organizational insiders (Bauer & Erdogan, 2012). Studying organizational socialization entails a focus on the perspectives and approaches of individual newcomers, as well as on features of the organization, such as its norms and cultures (Bauer & Erdogan, 2012).

Very little research has been conducted on organizational socialization in engineering workplaces, and (prior to this study) none has been longitudinal or mixed-methods. Chao et al. (1994) conducted a survey examining relationships between six dimensions of socialization and career effectiveness and job and organization changes. More recently, Korte and colleagues conducted an interview study of newcomer engineers at one manufacturing company (2009, 2010, 2013, 2015). As presented in Figure 1, when examining organizational socialization in engineering workplaces specifically, Korte found that relationship-building was the key driver for organizational socialization, and that the work group was more important than the organization as a whole (Korte, 2009, p. 295). Korte's model can provide a framework for conceptually locating where newcomers' challenges occur, if that changes over time, and if the locations differ for different groups of people.

Figure 1: Korte's model of organizational socialization in engineering

Methods

Methodology

The larger project of which this paper is one part is a mixed-methods, but highly qualitative study designed to examine the experiences of a small number of participants' in depth in order to develop grounded theory (Charmaz, 2006) about a little-studied topic. Data collection will be done though both interviews and surveys. The surveys are intended to systematically track changes in these participants over time; they are not intended to constitute a quantitative study in and of themselves. As a theory-building research project, this project does not aim for statistical significance. The aim of the project is to develop new, theoretically significant insights that can subsequently be further developed and tested, rather than statistically significant data. Quantitative data and surveys do not lend themselves to understanding experiences, complexity, or emergent themes. Because the aim of this project is to learn about newcomers' experiences, perceptions, and decision-making regarding a largely unstudied topic, qualitative interviews are the most appropriate data collection method. Qualitative interviews provide fuller, deeper, and more detailed descriptions than quantitative, closed-answer, or written surveys (Singleton & Straits, 2010; Weiss, 1994). In-depth interviews allow researchers to learn about participants' thoughts, perceptions, and interpretations in ways that allow insight into their subjectivities (Patton, 1990; Weiss, 1994). In-depth interviews allow for salient issues to emerge during the course of the study in ways that closed-answer surveys cannot when the range of issues is already prescribed. This is what is needed for grounded theory development. Furthermore, qualitative interviews can be used to identify variables and issues and frame hypotheses for subsequent quantitative research (Weiss, 1994), thus positioning this line of research to be scaled-up in future studies.

Participants and recruitment

Participants were recruited through national and regional engineering education and civil engineering listservs (group electronic mailing lists), social media postings, and emails sent out by engineering faculty members. While much effort was made to recruit a racially-diverse group of participants and an equal number of men and women, these efforts were not entirely successful. Twelve women and six men participated. Eleven identified as white, three identified as hispanic or latina/o, three identified as a combination of white and another race or ethnicity, and one identified as black. The black participant was originally from a different country, and the rest were from the United States. They worked in six different states at seventeen different companies and attended nine different universities for their undergraduate degrees. Seventeen had undergraduate degrees in civil engineering and one was in environmental engineering. Four already had, or were pursuing, Master's degrees, at four different universities. All participants worked in civil engineering positions in civil engineering companies. They had been in their jobs for an average of a little over one year.

Table 1: Overview of participants

Number of Participants	18
Women	12
Men	6
Companies represented	17
States represented	6
Nationalities	2

Data collection and analysis

Interviews were conducted online in 2019. Participants were asked the following questions: What were your first impressions of your workplace? What is the biggest challenge you have faced since starting your job? What has been the most surprising thing about your job? How do you feel your education prepared you to do your job? How would you describe the culture

or environment of your workplace? Do you think there is anything unfair or unjust about your workplace? For this paper, responses pertaining to the biggest challenge question were analysed through open coding (Charmaz, 2006) to determine if any themes could be identified in participants' responses. Participant names used in this paper are pseudonyms.

Findings

No one leading theme dominated the responses. Responses covered a very wide range of issues. However, there were three themes of note that appeared in at least four different participants' responses. They were: 1) interdependence, 2) new practices and material, and 3) negative interactions. Table 2 summarises the findings.

Table 2: Summary of challenges

Challenge	Description	Experienced By
Interdependence	Having their work be dependent on others, in contrast to school	Men and women
New practices & material	Lack of knowledge needed to perform their tasks	Men and women
Negative interactions	Interactions with clients, supervisors, or co-workers experienced as a problem	Women only

Interdependence

Four participants described their biggest challenge as having to adjust to their work being inextricably interdependent with other people's work, contrasting it with how they were able to be entirely in control of their own work when they were students. The following quotations reveal how three participants experienced this new interdependence:

> *I'd say probably just integrating into a life of – you know, when you are in school, you are on your own. You study on your own, well at least I did because that was the easiest thing for me…but this field that I'm in, everything goes hand in hand, and everyone has to work together. So you might have your own separate part of the project but at some point you're going to have to integrate in with everybody else. So, I think just that integration of – 'I can't just do my work' now, and integrating into a team…* (Lynnette)

> *That very first month I struggled adapting to what the demands of industry were as opposed to academia. The demands of academia were dependent on myself only. Whereas the demands of the industry depended on the team as a whole, so my work was directly correlated to the success of the next person's job on the team and so on and so forth. Everybody depended on each other's work to be accurate… to be able to move forward and progress in the project successfully. And I found that out the hard way because it was part of the learning curve.* (Liam)

> *The biggest challenge is adjusting the way that I work because in school I could take however much time I needed to do something. Like, I'd have a task, and I'd have a deadline, and I'd just do what I needed to do to get that done. But now at work … having to budget my time and do things based on how other people think they should be done instead of at my own pace or my own flow when I feel like it.* (Margaret)

Interdependence was part of a larger number of responses about working with people in general. For example, other participants discussed the amount of networking involved and having to learn how to navigate different management styles.

What these responses conveyed as the challenge was not necessarily the technical or logistical knowledge of *how* to coordinate. Rather, it was the more basic *fact that* their work was now interdependent. The challenge was adjusting to a mode of work that took away the autonomy they were accustomed to in school. From school, they were accustomed to being able work alone, at their own pace, when they wanted, independent from others.

New practices, content and material

Four participants described their biggest challenge as having to learn new technical material, rules of practice, and/or norms about how they were supposed to work. For instance, Tom said:

> *My first assignment was to create a set of plans, and I had zero idea how to do it. I didn't know what to do, and I thought I was going to get fired for not knowing how to do it, which looking back on it now was a very stupid thing to think. Of course I didn't know anything! And the company knew that, so of course they weren't going to fire me for that. So, I guess the biggest challenge for me was trying to overcome this thought that I wasn't good enough or that I was stupid just because I didn't know any engineering terminology or anything else really…*

Similarly, Steven said:

> *It probably was a lot of the content of what I was doing. There was a lot of it that was not taught in school… A lot of learning the rules of practice, ways things are done within a specific industry, was probably the most challenging.*

James described having to learn all the material from his industry, which he had never taken any classes in. He had to learn about new code books and there was a lot of "learning on the go." Lisa recounted an example of doing a lot of unnecessary work to calculate a correct pipe size the way she was taught in school, only to later find out that she did not need to do that because the pipe size was already determined for her, and her supervisor was unhappy about the time she had wasted.

Negative interactions

Negative interactions on the job were reported by four participants as their biggest challenge. Two of these interactions were with co-workers, one was with a supervisor, and one was with clients. Their stories were too long to be quoted directly in this paper but are summarised here.

Nina reported that she did not feel like her voice was heard by her supervisor. When she brought issues to her supervisor's attention, he would often ignore it and/or never follow up about it.

Lisa recounted challenges she faced regularly when working with clients, namely that they would not talk to her and/or not look at her. Even if she was the primary person working on their project, if a male engineer was at the meeting, even if it was his first day on the project, the client would only talk to the man. She summed it up as: "The challenge is when the client doesn't respect women as thinkers, engineers, or decision-makers."

Amy reported an instance of harassment, although she did not call it that. Another early career engineer "hounded" her about going out with him and "constantly" asked for her phone number. She turned down all of his requests, but he did not stop, and the harassment went on for several months until a co-worker overheard and reported it.

Helen, who is black, was confused and bothered by several interactions with co-workers. In one case, a man who sat near her would never speak to her, even though he spoke to other new engineers who were white.

Discussion: Implications for Engineering Education

Interdependence

Trevelyan (2010a) identified "technical coordination" as the essence of engineering work. Findings presented here revealed one salient instantiation of how technical coordination manifested as a challenge for first-year engineers, specifically, the interdependence required to accomplish their work. Based on prior literature, interdependence has been identified as one of the primary outcomes that instructors should strive for when teaching teamwork in engineering courses (Borrego, Karlin, McNair, & Beddoes, 2013). Interdependence is defined as "the level of reliance one person, group, or organization has on others in order to complete their work" (Borrego et al., 2013, p. 488). More specifically, "intensive interdependence" is what

participants in this study described, and it is the type of interdependence that instructors should aim for. The findings presented here provide even further evidence of the need to promote and actively develop interdependence during teamwork in engineering courses in order to better prepare graduates for the intensive interdependence that they face in their jobs. With a growing number of work- and practice-based programs in Australia (e.g., Cook et al., 2017; Daniel & Mann, 2018; Morgan, Lindsay, & Sevilla, 2017), there are increased opportunities for students to gain experience with interdependence. Further information on types of interdependence and how to promote it in student teams can be found in Borrego et al. (2013). Resources such as *The Making of an Expert Engineer* (Trevelyan, 2014) can also help prepare students for the interdependence required in the workplace.

New practices and material

As others have noted, there is a gap between engineering education and practice that can pose significant challenges for recent graduates (Trevelyan, 2010b). Given the relative breadth of work encompassed under civil engineering, this challenge may be somewhat more pronounced for civil engineers than for other engineering disciplines. In any case however, these findings highlight the need for more work- and practice-based learning. The findings also point to an opportunity for instructors to explicitly identify when what they are teaching will be different in industry. Lisa's story of having wasted time calculating pipe size, for example, evidences how such a discussion in class would have saved her time and prevented dissatisfaction from her supervisor. Additionally, instructors could inform students how common it is for recent graduates to feel like they do not know how to do anything in their new jobs, so they should anticipate that may be the case. Indeed, in other parts of the interviews, several participants noted that their professors had done just that, and it had helped them to not be surprised by their new jobs. It is worth noting that all of the participants had done one internship, and many had done two internships, and even those had not been sufficient to prevent these challenges.

Negative interactions

All of the participants who cited negative interactions as their biggest challenge were women, and their negative interactions were with men (although Helen also reported a negative interaction with a woman). Their stories add to an ever-growing body of research on gender in engineering (Male & MacNish, 2015; Male et al., 2018; Mills et al., 2014; Bryce, Far, & Gardner, 2019) and highlight that gender biases and harassment are not things of the past. This is the most difficult theme about which to make recommendations for engineering education. Engaging equity issues is usually not seen as part of the engineering educator's job (Beddoes, 2019), and laments over an already crowded curriculum are quickly invoked to maintain those boundaries. Very few initiatives have attempted to integrate equity discussions directly into engineering curricula. Indeed, some engineering instructors see it as a good thing to let women have negative experiences in classes to prepare them for what they will face in industry (Beddoes & Panther, 2018). While there are no easy answers here, these and other gendered aspects of the data will be discussed in further detail in future work.

Conclusion and Future Work

The three most common biggest challenges experienced by first year civil engineers were interdependence, learning new practices and material, and negative interactions. These findings point to several ways that instructors could better prepare students for the transition to work. They also highlight issues of gender that remain a problem and require new solutions.

In addition to providing insights into job readiness, the findings speak to several aspects of organizational socialization. Most participants' biggest challenges (in the form of *interdependence* and *new practices and materials*) were related to "learning & adaptation." Challenges related to "relationship building" and "work group socialization tactics" (in the form of *negative interactions*) were only the biggest challenges for women, not men. However, negative interactions also extended beyond factors accounted for in current models of

organizational socialization, and should therefore be accounted for in revised models. Such gender differences may have implications for retention because early career women engineers leave engineering at much higher rates than early career men (Fouad et al., 2012; Glass et al., 2013).

How and where challenges shift over time remains to be seen. Examining those shifts will provide new insights into the *process* of organizational socialization. The overarching goal of the project is to better understand the experiences of early career civil engineers, identify salient variables in attrition from engineering careers, and develop a model to explain those phenomena. To that end, this longitudinal study will continue data collection for four years. These same participants will be interviewed every six months and complete an online survey every two months. In this way, while the number of participants is not large, the study will produce a large amount of data. In order to try to retain participants in the study over the course of four years, the project includes a relatively large incentive plan with each participant receiving $1000 over the course project, in increasing amounts each year. Through the multiple contact times, I am also building relationships that I hope will support retention.

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