Understanding Adaptability in the Engineering Field

by

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A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Approved June 2022 by the
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ARIZONA STATE UNIVERSITY

August 2022

ABSTRACT

Adaptability has emerged as an essential skill in the engineering workforce due to constant technological and social change, engineering grand challenges, and the recent global pandemic. Although engineering employers and national reports have called for increased adaptability among engineers, what adaptability means in the engineering workplace has not been investigated. This dissertation uses qualitative semi-structured critical incident interviews with engineering managers from four corporations to better understand their perceptions of adaptability and then incorporates these findings into a scenario-based intervention for the engineering classroom.

Thematic analysis of the interviews with engineering managers expanded existing frameworks for workplace adaptability to provide an engineering-specific understanding of adaptability as a construct. Managers' perceptions of adaptability span six dimensions, each important when teaching this competency to engineering students: Creative Problem Solving; Interpersonal Adaptability; Handling Work Stress; Dealing with Uncertain and Unpredictable Situations; Learning New Technologies, Tasks, and Procedures; and Cultural Adaptability. Managers' beliefs about the importance of a balanced approach to being adaptable in different work contexts, and the influence of personal characteristics such as self-awareness and having had specific experiences related to being adaptable, emerged from the findings as well.

Composite narratives reflecting real-life situations encountered by engineers in the workplace were developed based on findings from the engineering manager interviews to provide greater texture to the data. Six of the narratives mapped to the six dimensions of adaptability identified in the thematic analysis, while the seventh narrative illustrated the importance of balance and context when deciding whether and how to be adaptable. They revealed how multiple dimensions of adaptability work

together and that contextual factors like support from managers and coworkers are integral to an engineer's adaptability.

The narratives were condensed into two scenarios for use in a classroom-based intervention with first-year engineering students at a large public university. After the intervention, many students' definitions of adaptability became more multi-dimensional and reflective of adaptability context and balance. Students also reported a better understanding of engineering work, an expanded definition of adaptability, greater delineation of adaptability, increased self-awareness, greater appreciation for the importance of adaptability balance, and enhanced feelings of job preparedness.

DEDICATION

This dissertation is dedicated to my life partner, Mark Huerta. I am forever grateful for your continuous support. Thanks for being there through all the ups, downs, and turns in the journey and keeping me grounded.

I also could not have done this without the support of so many. Thank you to my family for giving me such support and joy throughout this journey. To my younger brother Sassan, who always makes me feel better with his humor—and was the subject of many practice interviews. Thank you to my sister Alejandra for her constant support and advice—I was truly blessed with the best big sister. With her guidance and support, I had courage to take the risks that brought me here today. To my parents, who are the most inspiring people I know—who have overcome so much to provide me with the opportunities I have and have taught me to work hard and be resilient. To the many friends who had talked through ideas with me and been supportive when I was stuck. Thank you, especially to my dear friend Aimen Vanood—who was a constant source of encouraging words and helped me celebrate each milestone on this journey.

ACKNOWLEDGMENTS

1. As a student of ASU, I acknowledge that the Tempe campus sits on the ancestral homelands of those American Indian tribes that have inhabited this place for centuries, including the Akimel O'odham (Pima) and Pee Posh (Maricopa) peoples. "In keeping with the design aspirations of the New American University, ASU seeks to embrace our place, connect with tribal communities, and enable the success of each American Indian student. We reaffirm the university's commitment to these goals and acknowledge that everyone, the entire ASU community, is responsible for their achievement." President Crow, August 31, 2015

2. I would like to express my gratitude to my advisor Dr. Samantha Brunhaver for the opportunity to work on my research project and for her guidance and support throughout my doctoral journey. I also want to extend my gratitude to my committee members Dr. Nadia Kellam and Dr. Ann McKenna for their guidance in my research and for taking the time to serve as committee members. I have learned so much through this process!

3. Thank you to my classmates, and the ASU Writing Center Staff for all your help. I also want to extend my gratitude to the participants in these studies!

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INTRODUCTION

Nick Donofrio, fellow emeritus at the IBM Corporation, stated during a recent national workshop on the adaptability of the U.S. engineering and technical workforce that "[t]he continually changing demands of the workplace have created an imperative for workers to be adaptable. People need to be able to innovate and change in a collaborative, open, and inclusive way" (National Academies of Science, Engineering, and Medicine, 2018, p. 3).

Indeed, the ability to adapt has become significant in today's engineering workforce (National Academies of Science, Engineering, and Medicine, 2018) as the world undergoes its Fourth Industrial Revolution, marked by rapid advances in artificial intelligence, machine learning, the Internet of Things (IoT), and autonomous vehicles, among other computing-related technologies. While engineers and engineering work have always needed to adapt to keep up with changing technology and deliver the most timely and innovative solutions to these issues (Schwab, 2016), the current pace of technological development has far exceeded that of any time prior (McGowan & Shipley, 2020). Rapidly changing technology has led to increased cross-disciplinary interactions, globalization, and changing organizational structures in the workplace, changing how engineers work and collaborate (Duderstadt, 2008; Johri & Jesiek, 2014). Professions of all kinds have also been impacted by significant social, economic, environmental, and health crises currently unraveling on the national and global stages (e.g., Lund et al., 2021, Deloitte, 2021; Brown et al., 2017).

Fostering adaptability can act as an appropriate strategy to begin addressing and coping with these rapid changes occurring in engineering. Yet, a growing body of evidence suggests that engineers at all career levels struggle to adapt. Deming and Noray

(2018) found that engineering and other STEM jobs experience the highest rate of technological change but the lowest rate of learning new skills and technologies relative to other occupations. These findings are further supported by Brunhaver et al. (2018), who showed that early-career engineering graduates struggle with the transition from school to work, and Korte et al. (2015, 2019), who showed that later-career engineers have similar difficulty with the need to upskill and reskill, pointing to a need for greater adaptability training.

Calls to integrate adaptability more intentionally into engineering curriculum date back at least three decades (National Research Council, 1990) and have come from industry (Ben-Naceur, 2019; McMasters & Natch, 1996), national organizations (NASEM, 2018; National Association of Colleges and Employers, 2018), and professional societies in various engineering fields (American Society of Civil Engineers Body of Knowledge Task Committee, 2019; American Society of Mechanical Engineers, 2020; Institute of Electrical and Electronics Engineers, 2019). They have also come from engineering managers, educators, and engineers themselves (Davies et al., 1999; Lattuca et al., 2014). These calls have been partly motivated due to the many anticipated benefits of having greater adaptability in the engineering workforce, including increasing its size, productivity, and national competitiveness (NASEM, 2018). There is thus a need to explore ways that help engineers become more adaptable.

Adaptability in Engineering Education

Two main challenges to greater adaptability development in engineers exist. The first challenge is that engineering lacks a shared understanding of what adaptability means. While the general body of research examining adaptability is growing, scholarly research into engineering adaptability remains limited, with only a few exceptions

(Saraswathiamma, 2010; Sirotiak & Sharma, 2019). In addition, while adaptability can be broadly defined as the ability to respond to change effectively, no existing literature explores the meaning of adaptability in the context of the engineering workforce specifically. In fact, the National Academy of Engineering described adaptability in its *Engineer of 2020* (NAE, 2004) report as "something that cannot be described in a single word" (p. 56). Thus, the traits and behaviors that make up engineering adaptability need to be clarified for adaptability training within engineering to be effective.

The second challenge to adaptability development in engineers is that while adaptability is generally seen as an important skill for engineers, it is not typically taught within formal undergraduate engineering education. Existing approaches to fostering adaptability tend to emphasize problem-based, project-based, and experiential learning for students and on-the-job training and rotational assignment programs for early-career professionals (NASEM, 2018). While these techniques have been shown to have meaningful impacts, it is unclear whether they nurture an individual's ability to adapt or merely test it. Since about 2000, there has been a shift to intentionally integrate other professional skills (e.g., multidisciplinary teaming, engineering ethics, communication, and knowledge of contemporary issues) into the formal engineering curriculum, partly in response to changes in ABET accreditation standards (Shuman et al., 2005). Several researchers have found that these skills are best learned by students when they are explicitly taught in the classroom (e.g., Care et al., 2016; Daly et al., 2014). This dissertation hypothesizes that students best grow in their awareness and learning of adaptability when it is explicitly defined and taught as well.

The research questions addressed in this dissertation are thus as follows:

1) What are engineering managers' perceptions of adaptability?

a. How do engineering managers define adaptability in the engineering field?

b. What are some situations to which engineers must adapt in the workplace, as described by engineering managers?

2) What are engineering students' perceptions of adaptability?

a. What are engineering students' perceptions of a scenario-based classroom intervention on adaptability?

b. What are engineering students' definitions of adaptability before and after a scenario-based classroom intervention on adaptability?

To address research question 1A, engineering managers from four companies were interviewed about their perspectives on adaptability using the critical incident technique. During the interviews, managers identified various dimensions of adaptability critical to engineering work and discussed other personal and contextual factors which might affect when, how, and to what extent an engineer adapts as well.

To address research question 2B, composite narratives based on the critical incidents shared by managers were developed to provide deeper understanding of each adaptability dimension and how they interact. These composite narratives added texture and detail to the critical incidents, weaving elements of different situations into a single story and allowing for more complex depictions of real-life situations to which engineers have needed to adapt to be shared.

To address research questions 2A and 2B, an intervention was conducted in a first-year design project-based engineering course. Students were presented with condensed versions of the composite narratives, called scenarios, to determine to what extent an intervention using scenario-based learning could influence their perceptions of adaptability. Three types of responses were collected from students: 1) their definitions of adaptability before and after the intervention, 2) their proposed approach to each adaptability scenario during the intervention, and 3) their post-activity reflections on what they had learned about adaptability as a result of engaging with the scenarios. Students' definitions of adaptability resembled those of engineering managers and became more multi-dimensional and reflective of adaptability dimensions emphasized in the scenarios after the activity. Students also identified multiple benefits of having participated in the scenario-based intervention.

The findings from this work will address a gap in the literature around engineering adaptability and help inform future approaches for teaching adaptability to engineering students and professionals. The ultimate result will be fostering greater understanding of adaptability in different work contexts, thereby better preparing engineering graduates for the transition from engineering education to engineering industry.

Organization of this Dissertation

This dissertation consists of three components: qualitative critical incident interviews with engineering managers, the development of composite narratives based on the engineering manager interviews, and a scenario-based classroom intervention derived from the composite narratives. The literature review, methods, and results and discussion chapters are organized into sections corresponding to these three outputs. Lastly, there is a conclusion chapter that summarizes the results of these outputs and provides recommendations for employers, educators, and researchers.

CHAPTER 2

LITERATURE REVIEW

Defining Adaptability

Initial research on adaptability began in the field of psychology. Since then, terms such as adaptability (Smith et al., 1997), adaptive performance (Allworth & Hesketh, 1999), adaptive expertise (Chen et al., 2005), adaptive abilities (Karaevli & Hall, 2006), adaptive behavior (Karaevli & Hall, 2006), flexibility (Hill et al., 2008) and adaptivity (Griffin et al., 2010) have been used to describe workplace adaptability in the literature.

Definitions for adaptability have usually been presented as multi-faceted, spanning multiple adaptability dimensions. For example, Allworth and Hesketh (1999) defined adaptive performance as demonstrating the ability to cope with change and transfer learning from one task to another as job demands vary, emphasizing both a cognitive component related to problem solving and a non-cognitive component related to emotional adjustment. Likewise, Bohle Carbonell et al. (2016) defined adaptive expertise as containing both domain-specific and innovation skills.

Scholars have also described adaptability as having different levels, with most definitions focusing on the individual and task levels. Definitions of adaptability at the individual level tend to focus on individuals' ability, willingness, and intent to adapt. Ployhart and Bliese (2006) defined individual adaptability as "an individual's ability, skill, disposition, and willingness and/or motivation to change or fit different tasks, social environments, or environmental features" (p. 13). By contrast, definitions of adaptability at the task level tend to focus on individuals' actions in response to a particular stimulus (Shoss et al., 2012). For example, Ivancic and Hesketh (2000) defined adaptive transfer at the task level as "using one's existing knowledge base to change a learned procedure or generate a solution to a completely new problem" (p. 1968). Notably, Baard et al. (2014) began the process of combining these two different perspectives on adaptability, defining it as the "cognitive, affective, motivational, and behavioral modifications made in response to the demands of a new or changing environment, or situational demands" (p. 50). In putting forth this definition, Baard et al. addressed both individual (cognitive, affective, motivational) and task (behavioral) elements of adaptability.

One of the more comprehensive definitions of workplace adaptability that accounts for both the cognitive and emotional and the individual and task level components of adaptability is Pulakos et al.'s (2000) concept of adaptive job performance. Pulakos et al. (2000) deviate from other definitions of adaptability in that they defined adaptive performance not with a singular definition but as a set of eight behavioral dimensions identified through analysis of over 1,000 critical incidents from 21 different jobs within 11 different military, federal government, state government, and private sector organizations. These dimensions (Table 1) include handling emergencies or crises; handling work stress; solving problems creatively; dealing with uncertain and unpredictable work situations; learning new tasks, technologies, and procedures; demonstrating interpersonal adaptability; demonstrating cultural adaptability; and demonstrating physically oriented adaptability.

While Pulakos et al.'s (2000) framework for adaptive performance is a useful starting point for understanding workplace adaptability, the specific adaptability dimensions relevant to a particular employee will vary depending on such characteristics as their type of organization, available job support, and specific job demands (Park & Park, 2019). Charbonnier-Voirin and Roussel (2012) instrumented Pulakos et al.'s (2000) eight dimensions of adaptive performance with a sample of French employees in the telecommunications, aircraft, and service industries and identified five similar dimensions in a factor analysis of the responses, including creativity, reactivity, interpersonal adaptability, training and learning, and managing stress; however, physically oriented adaptability did not emerge as a factor in this study. Elsewhere, Kantrowitz (NASEM, 2018) analyzed the adaptability requirements of specific occupations (i.e., research scientist, engineer support, law enforcement, installation and repair). Whereas all eight dimensions of adaptive performance emerged as critical to law enforcement occupations, only handling work stress; solving problems creatively; dealing with uncertain and unpredictable situations; learning new tasks, technologies, and procedures; and demonstrating interpersonal adaptability were determined to be important to scientific and technical occupations (NASEM, 2018). These studies not only reiterate that adaptability is multidimensional but also indicate that different jobs have different adaptability demands and that further investigation is needed into specific sub-fields (e.g., engineering) to capture their domain-specific nuances.

Table 1

Pulakos et al.'s (2000) Dimensions of Adaptability

Behavior	Description
Solving problems creatively*	Employing unique types of analyses and generating new, innovative ideas in complex areas; turning problems upside-down and inside-out to find fresh, new approaches; integrating seemingly unrelated information and developing creative solutions; entertaining wide-ranging possibilities others may miss, thinking outside the given parameters to see if there is a more effective approach; developing innovative methods of obtaining or using resources when insufficient resources are available to do the job.
Handling work stress*	Remaining composed and cool when faced with difficult circumstances or a highly demanding workload or schedule; not overacting to unexpected or new situations; managing frustration well by directing effort to constructive solutions rather than blaming others; demonstrating resilience and the highest levels of professionalism in stressful circumstances; acting as a calming and settling influence to whom others look for guidance.

Dealing with uncertain and unpredictable work situations*	Taking effective action when necessary without having to know the total picture or have all the facts at hand; readily and easily changing gears in response to unpredictable or unexpected events and circumstances; effectively adjusting plans, goals, action, or priorities to deal with changing situations; imposing structure for self and others that provide as much focus as possible in dynamic situations; not needing things to be black and white; refusing to be paralyzed by uncertainty or ambiguity.
Learning new tasks, technologies and procedures*	Demonstrating enthusiasm for learning new approaches and technologies for conducting work; doing what is necessary to keep knowledge and skills current; quickly and proficiently learning new methods or how to perform previously unlearned tasks; adjusting to new work processes and procedures; anticipating changes in the work demands and searching for and participating in assignments or training that will prepare for these changes; taking action to improve work performance and deficiencies.
Demonstrating interpersonal adaptability*	Being flexible and open-minded when dealing with others; listening to and considering others points of view, and opinions and altering own opinion when appropriate to do so; being open and accepting of negative or developmental feedback regarding work, working well and developing effective relationship with highly diverse personalities; demonstrating keen insight of others behavior and tailoring own behavior to persuade, influence, or work more effectively with them.
Demonstrating physically oriented adaptability	Adjusting to challenging environmental states such as extreme heat, humidity, cold, or dirtiness; frequently pushing self physically to complete strenuous or demanding tasks; adjusting weight and muscular strength or becoming proficient in performing physical tasks as necessary for the job.
Demonstrating cultural adaptability	Taking action to learn about and understand the climate, orientation, needs, and values of other groups, organizations, or cultures; integrating well into and being comfortable with different values, customs, and cultures; willingly adjusting behavior or appearance as necessary to comply with or show respect for others' values and customs; understanding the implications of one's actions and adjusting approach to maintain positive relationships with other groups, organizations, or cultures.
Handling emergencies or crisis situations	Reacting with appropriate and proper urgency in life threatening, dangerous, or emergency situations; quickly analyzing options for dealing with danger or crises and their implications; making split-second decisions based on clear and focused thinking; maintaining emotional control and objectivity while keeping focused on the situation at hand; stepping up to take action and handle danger or emergencies as necessary and appropriate.

Note: * denotes the five dimensions identified by Kantrowitz as important for scientific and technical occupations (NASEM, 2018).

Composite Narratives

Composite narratives are used in this study to combine the critical incidents from engineering managers into rich, texturized stories of engineers demonstrating adaptability in the workplace. Composite narratives are a relatively modern methodology used in the existing literature for several purposes: to do justice to complex accounts while maintaining participant anonymity (Creese et al., 2021; Johnston et al., 2021; Willis, 2019), summarize data in a more engaging personal form and retain the human face of the data (Creese et al., 2021), represent specific aspects of the research findings (Johnston et al., 2021), enhance the transferability of research findings by invoking empathy (Wertz et al., 2011), illuminate collective experiences (Porter & Byrd, 2021), and enhance research impact by providing findings in a manner that is more accessible to those outside of academia (Willis, 2019). Further, composite narratives leverage the power of storytelling, shown to be effective in studies of neurology and psychology; i.e., since humans often think and process information in narrative structures, information conveyed in story form can be imprinted more easily on readers' minds or existing schema (Roche & Sadowsky, 2004; Wertz et al., 2011). The composite narratives in this dissertation leverage several of these benefits, allowing for more nuanced understanding of adaptability, its dimensions, and its influencing factors to develop. Truncated versions of these composite narratives are then used in a scenario-based classroom activity around adaptability, providing an intervention planted in the research work.

Teaching Adaptability More Intentionally

This section explores the utility of scenario-based training as a way to foster adaptability. Scenario-based learning is an inquiry-based learning pedagogy in which learners apply their disciplinary knowledge, critical thinking, and problem-solving skills to examine a specific scenario (National Research Council, 2011). Scenario-based learning uses interactive scenarios to simulate real-life practice and help learners close the gap between theory and application (Errington, 2011). Grounded in situated learning theory (Lave & Wenger, 1991), scenario-based learning connects to what learners will realistically encounter in their work but does not necessarily involve authentic cases (Sheridan & Kelly, 2012).

Further, scenario-based learning is a well-supported strategy for STEM teaching (National Research Council, 2011). While there have not been many documented efforts to teach workplace adaptability specifically to engineering students, scenario-based learning has been used to foster adaptive expertise-related skills in engineering design (McKenna, 2007). Scenario-based learning has also been used within engineering education as an effective way to engage learners and build competency-based mastery in other engineering competencies such as engineering ethics (Musib, 2019), and statics (Shih et al., 2004).

Adaptability has been established as a critical competency for workers in many disciplines beyond engineering, and scenario-based training has been used to foster adaptability in some of these disciplines. For example, scenario-based training has been shown to improve the adaptive performance of workers such as military soldiers (Salas et al., 2006; Duffy, 2010) and pre-service teachers (Granziera & Martin, 2016). It is, therefore, hypothesized that scenario-based learning could also be a useful strategy for teaching adaptability in the engineering education context.

Given the potential promise of scenario-based learning methodologies for enhancing students' adaptability development, this dissertation explores the use of scenario-based learning for teaching adaptability to first-year engineering students. In this work, the composite narratives depicting common situations to which engineers must adapt were condensed into interactive scenarios. The scenarios were then implemented in the classroom to determine to what extent a scenario-based intervention can influence students' perceptions of adaptability.

Summary

The literature on adaptability supports that adaptability is a multidimensional and complex construct warranting further investigation, especially to define it in the context of specific job roles such as engineering. Further, the literature indicates that scenario-based learning particularly may be effective for fostering the development of skills such as adaptability. This dissertation uses critical incidents provided by engineering managers to develop composite narratives of engineers being adaptable in the workplace and then leverages these composite narratives to create scenarios for use in a classroom-based intervention related to adaptability and grounded in the research.

CHAPTER 3

METHODS

Overview

This dissertation consists of three components: qualitative critical incident interviews with engineering managers, composite narratives, and a scenario-based classroom intervention. Each methodology is related since the interviews informed the development of the narratives, and the narratives informed the development of the scenarios. In this chapter, descriptions of these methodologies will be shared, including the processes for developing one composite narrative based on multiple critical incidents from the manager interviews and for converting these longer narratives into short-form scenarios to present to students. Together, the methodologies used in this research provide a foundation to understand adaptability in the engineering field and to improve adaptability development for engineering students.

Researcher Positionality

Recognizing the importance of researcher positionality in the research process, I share a bit about my background. I have a bachelor’s and master’s degree in biomedical engineering and, therefore, am familiar with the engineering curriculum. I worked as an engineer at multiple companies and later in corporate social responsibility related to STEM education before pursuing my Ph.D. in engineering education. I bring to this research my own experiences in working as an early-career engineer and an awareness of the engineering workplace environment and its culture. My experiences include working on male-dominated teams as a woman of color (at times being the only woman on a technical team or in my department). My own experience gives me increased empathy for those in that situation, as well as a personal connection to the idea of “adaptability balance” described in this dissertation.

Additionally, I have worked in higher education as an instructional professional and academic associate for engineering student teams working on service projects, and in K-12 education as a lead instructor teaching computer programming and other STEM topics. When designing my curriculum, I have often incorporated scenario-based learning and found it effective. I have also previously implemented scenario-based learning activities with engineering students on engineering workplace dynamics, which I expand on in this dissertation in the context of adaptability. I believe that giving students the opportunity and space to discuss their reactions to these scenarios is very helpful and, in particular, allows them to explore and consider multiple approaches in a safe space.

Interviews with Managers

Research Sites

Four research sites participated in this study, including one very large semiconductor company (>50,000 employees), one large semiconductor company (~30,000 employees), one midsize electronics company (~10,000 employees), and one medical device company (~10,000), all with offices in the southwestern United States. These sites were selected for this study for several reasons. The intention was that the companies would have local offices to the Phoenix metro area, where Arizona State University campus is located, to enable observation (although this part was abandoned in the wake of the COVID-19 pandemic and shift to remote working conditions). Regional ties and personal connections were used to aid in recruitment. Further, like many engineering companies, these sites are affected by rapidly changing consumer demands, short product lifecycles, and regulatory requirements (e.g., Batur et al., 2018;

Benham et al., 2020; Khan, 2017), requiring adaptability of their engineers and thus making them interesting sites to study. Notably, these sites also faced a shift to remote work, supply chain disruptions, and the reallocation of resources to manufacture pandemic-related medical products during the COVID-19 pandemic, with which data collection for this study overlapped. While these circumstances were not foreseen during the site acquisition stage, they additionally contributed to the richness of the data obtained from these sites during the data collection stage.

Participant Recruitment

A project liaison was identified and communicated with at each research site. The project liaisons were senior engineering managers or other employees in senior leadership positions within the engineering organization. Each liaison was asked to help recruit engineering managers with diverse experience levels and demographics in their companies. The recruitment process for each company took varying lengths of time due to some requiring non-disclosure agreements. The managers whom liaisons recommended to be interviewed were then contacted via email regarding participation in the study. Participants were offered a $40 Amazon gift card and a certificate of community service recognition as incentives to participate in the interview. However, several managers declined the incentives and were willing to assist without them.

Participant Demographics

Seventeen managers from across the four research sites were interviewed – five from the very large semiconductor company, four from the large semiconductor company, four from the midsize electronics company, and four from the medical device company, as observable in Table 2. All managers had over 10 years of experience working in an engineering field. Eleven had worked in their current organizations for longer than 10 years, and all but one manager worked in the western United States. Of the 17 managers, there was a diverse mix of educational levels – four with bachelor's degrees, seven with master's degrees, one with a professional degree, three with a Ph.D., and the rest unknown. Most managers interviewed ranged between age 40 to 65 years old and were White and male, which reflects current demographics in engineering (National Center for Science and Engineering Statistics, 2021). Three managers were of South Asian or Indian descent, and another manager was of Middle Eastern/North African descent. Four women engineering managers were interviewed, which represents an oversampling of women compared to the engineering field as a whole.

Table 2

Manager to Company Mapping

Company	**Manager Numbers**
1 Midsized Medical Device Company	1, 2, 3, 16
2 Midsized Electronics Company	4, 5, 6, 17
3 Very Large Semiconductor Company	7, 8, 11, 12, 15
4 Large Semiconductor Company	9, 10, 13, 14

Data Collection

Interviews with engineering managers were conducted between October 2020 and May 2021. Because engineering managers have called for engineers to have increased adaptability, interviewing them to understand their perspectives about what exactly it means for engineers to be adaptable was appropriate. Further, due to their supervisory roles, engineering managers were considered among the best suited to observe the adaptable behaviors of engineers and help contextualize the broader organizational factors shaping engineers' work.

Each interview was semi-structured, approximately 60 minutes long, and conducted via video call due to the COVID-19 pandemic. The developed interview protocol (Appendix B) used the critical incident technique (Flanagan, 1954) to capture specific examples of times when engineers the managers supervised needed to adapt on the job and either exhibited good or poor adaptable behaviors. Given that Flanagan originally developed the critical incident technique to differentiate between effective and ineffective workplace behaviors from the perspective of U.S. Air Force supervisors (as well as pilots and flight instructors), using the critical incident technique to collect engineering managers' perspectives about what is needed to be adaptable in the engineering workplace was determined reasonable and appropriate. Managers were asked to describe for each incident the circumstances surrounding the situation, the actions and reactions of the engineer, the problems the engineer encountered and resources the engineer used or sought, and the outcomes of the situation, including the manager's appraisal of why the engineer was successful or unsuccessful and what the engineer could have done differently. As a warmup, managers were asked about their role and experience within the company, team culture, and organizational culture. They were also asked how they define adaptability in the context of engineering work and how they believe adaptability varies across engineers by experience level and background. Participants were sent a demographic survey to complete after the interview.

Data Analysis

Interviews were transcribed and cleaned before being entered into Dedoose Version 8.0, a software for managing, analyzing, and presenting qualitative and mixed-method research data. A hybrid deductive-inductive thematic analysis approach (Fereday & Muir-Chochrane, 2006) with multiple cycles of coding was used to analyze the interview transcripts. The first cycle involved open coding of the transcripts and theoretical memoing to generate codes related to managers' conceptualizations of adaptability (Saldaña, 2013). These initial codes were descriptive and numerous. Next, the second round of coding was completed, using a deductive analysis where each transcript was read and coded for statements related to Pulakos et al.'s (2000) eight dimensions of adaptive performance in a process known as provisional coding (Saldaña, 2013). After these two coding cycles, these codes were upcycled into overarching codes within Dedoose, with definitions for each code created based on the subcodes included within them. Some of these high-level codes took on the terminology used *in vivo* by engineering managers, such as "self-awareness," whereas the researcher defined others (e.g., "adaptability balance") or utilized the Pulakos et al. (2000) naming scheme.

A total of six dimensions of adaptability emerged, alongside two codes related to contextual influences on adaptability ("adaptability context" and "adaptability balance") and two codes related to personal influences on adaptability ("self-awareness" and "specific kinds of experiences"). The final codebook for the interviews with engineering managers is presented in Table 3.

Table 3

Codebook from Engineering Manager Interviews

Category	Code	Definition
Adaptability Dimensions	Creative problem solving	Engineers recognize and consider multiple solutions to a problem; they are capable of synthesizing large amounts of information to use in their problem solving process; they are also open to failure and learning from failure as they move towards a solution.
	Interpersonal adaptability	Engineers possess the ability to communicate effectively and flexibly with others, to work well in teams and other collaborative work environments, to listen to ideas outside of their own, and to be open and inclusive of other people in their communications.
	Handling work stress	Engineers are capable of meeting fast-changing deadlines and handling work stress and pressure while remaining calm and productive.
	Dealing with uncertain and	Engineers are capable of dealing with a high level of ambiguity, changing gears in response to

	unpredictable situations	unpredictable or unexpected events and circumstances, and making decisions with limited data.
	Learning new tasks, technologies, and procedures	Engineers can identify the technology, tasks, and procedures they need to learn related to their job; they possess the initiative required to learn these new knowledge and skills; they can also transfer their knowledge and skills to new engineering work contexts as necessary.
	Cultural adaptability	Engineers are capable of working with people across different cultures, disciplines, and functional units; they can identify and learn new values outside of their own and work to be inclusive of those differences.
Contextual Adaptability Influences	Adaptability context	Adaptability may present as different behaviors in different contexts, such as at different career stages and in different types of engineering roles (e.g., more related to efficiency than innovation in manufacturing vs. research and development). Additionally, different contemporary contexts may require individuals and organizations to adapt, such as working remotely due to the COVID-19 pandemic.
	Adaptability balance	There are times when engineers must take a balanced approach to adaptability, depending on the context and environment. This may mean pushing back on an environment not conducive to their growth or balancing different skills based on the situation (e.g., balancing between asking enough questions to effectively problem solve vs. asking too many questions to try to reach certainty in an ambiguous situation).
Personal Adaptability Influences	Self-awareness	Engineers are aware of their strengths and weaknesses and know how and when to adapt to align their skill sets, interests, and values to the situation at hand.
	Specific kinds of experiences	Engineers have specific kinds of experiences recognized by engineering managers as related to adaptability; these include having had a broad set of experiences, having worked across disciplines, having pursued higher education, or having pursued global education, and be applicable to technical problem solving specifically or general engineering work.

Inter-Rater Reliability

Excerpts to be coded were identified by a primary coder, and preliminary coding of the excerpts was discussed between the primary coder and a secondary coder to clarify each code's meaning. The primary and secondary coders then coded each excerpt independently, after which inter-rater reliability between the two coders was determined for each code using Cohen's kappa measure of agreement (Table 4). Every code had a Cohen's kappa value exceeding 0.60 (range: 0.62 to 0.82), indicating substantial agreement between coders.

Table 4

Inter-Rater Reliability

Code	Cohen's kappa Value
Dealing with Uncertain and Unpredictable Situations	0.82
Handling Work Stress	0.62
Creative Problem Solving	0.65
Learning New Tasks. Technologies, and Procedures	0.70
Interpersonal Adaptability	0.80
Cultural Adaptability	0.79
Adaptability Context	0.74
Adaptability Balance	0.78
Self-Awareness	0.79
Specific Kinds of Experiences	0.65

Limitations

This study has limitations, like all research. Recruiting a diverse sample of managers in terms of gender identity, racial and ethnic identity, experience level, and business unit was more challenging at some companies than at others. For example, while women engineering managers were oversampled in the dataset relative to their percentage in the engineering workforce, most women participants were recruited from the medical device company, with recruiting efforts at two companies (the large semiconductor company and midsized electronics company) not yielding any woman participants at all. Similarly, the average experience level of participants was skewed toward top-level rather than mid-level management. These imbalances persisted over multiple recruitment attempts, possibly due to choices in the companies and liaisons themselves (i.e., the representation of women engineers tends to be greater in the medical device industry than in the semiconductor industry, and liaisons tended to come from positions higher up in the company themselves, where the representation of women tends to be lower). These challenges reflect known obstacles in recruiting representative samples when collecting data from industry (Stevens & Vinson, 2016). Therefore, findings from this work are not intended to be generalizable to all contexts. At the same time, this research provides a starting place from which further work can be conducted.

Another limitation of the study pertains to technology. Although video calls have become a norm in the workplace, the interviews included some incidences of technical issues or managers that did not seem entirely comfortable with the video call format. The original study goal prior to the onset of the COVID-19 pandemic was to conduct in-person interviews, which also would have allowed the opportunity to collect observations of the company site. Instead, these interviews relied solely on the managers' descriptions of their organization and other publicly available information. Furthermore, the use of video conferencing for qualitative interviews has been cited to have both advantages and drawbacks compared to phone interviews (Irani, 2018). As an advantage, the video format did allow for interviews of engineering managers outside the researcher's local area, potentially providing a more varied perspective. It also allowed interviewers to be at their own homes in many cases, which could have made them more comfortable. As a potential disadvantage, some elements of bias may have been a part of participant responses due to the researcher's body language or outward characteristics, compared to having conducted the interviews via phone, for example.

Composite Narratives

Data Source

Data for the composite narratives came from the qualitative interviews with engineering managers and, specifically, from their recollections of critical incidents when engineers they supervised needed to adapt to the job. The composite narrative methodology wove together elements of different managers' recollections into a single story with added texture and details.

Seven composite narratives were developed. Six narratives mapped to the six dimensions of adaptability identified in the thematic analysis of manager interviews, while the seventh narrative illustrated the importance of balance and context when deciding whether and how to be adaptable. The seven composite narratives are shared in the results chapter. Each composite narrative allows for more complex depictions of real-life situations in which engineers have needed to be adaptable to be shared, thus providing a deeper and more accessible understanding of engineering adaptability for relevant stakeholders. These narratives also provide a starting point to discuss other themes identified in the data related to adaptability, such as adaptability balance.

Composite Narrative Development

Each composite narrative was developed using two to four excerpts from the manager interviews following the same methodology. To create the composites, the critical incidents shared by managers were first categorized by type of incident observed (e.g., reassigned to a new job role, or tasked with communicating with a supplier, etc.) and most prominent dimension of adaptability (e.g., dealing with uncertain or unpredictable situations, interpersonal adaptability, etc.). These incidents were then reviewed for level of detail; some narratives were longer with more rich details, while others were shorter with fewer details. The narratives with more rich details and conclusions became the main narrative threads for each of the composites. Other narratives featuring a similar type of incident or the same prominent adaptability dimension were then and used as supplementary data sources to fill in each narrative. Personal characteristics such as gender or name were not always shared within critical incidents; therefore, when developing the composite narratives, pseudonyms and pronouns were chosen at random (three male, three female, and one gender-neutral pronoun were used in total).

The composite narratives were written in the third person, mirroring how managers described situations their employees had experienced rather than situations they had experienced themselves. There is one exception, "The balancing act. . .", in which a participant describes some of their own experiences as a manager. There were also instances where the incident managers described had too much or insufficient detail. The researcher drew on their own engineering experiences to supplement the managers' accounts in these cases. For example, one manager's discussion of a design change required omitting some details for the company's privacy, as noted in "The sky is falling…". These details were then replaced with a more general explanation of the situation based on experiences the researcher had to maintain anonymity.

A detailed account of how one composite narrative was constructed is presented to demonstrate the quality and trustworthiness of the composite narrative methodology. This composite was developed from three critical incidents in which engineering managers described times when engineers were required to work entirely outside of the job role for which they had been hired. The title of the narrative was based on one engineering manager telling the engineer they were supervising, "So, we know that this is not necessarily what we hired you for…." (Manager 1). The narrative most closely relates to the adaptability dimension, *Dealing with Uncertain and Unpredictable Situations*, due to the uncertainty that managers described engineers feeling about the changing nature of their job role. However, each manager's recollections were associated with a different cause (e.g., project cancellation, company merger, market change), resulted in a different outcome, and featured varying levels of detail. By choosing three situations from which to create a composite narrative, a more complete story that succinctly touches on multiple challenges related to adaptability but is still grounded in the data could be told.

Bold, *italicized*, and underlined elements in Table 5 and Figure 1 below visually represent how the three interview excerpts corresponding to Manager 1, 2, and 3, respectively, came together in the full narrative. Quotation marks denote exact quotes of what managers recounted saying to their engineers, and modifications to the excerpts were made for flow or clarity. Presenting the methodology in this format was inspired by Johnson et al. (2021).

Table 5

Composite Narrative Example

Composite Narrative Excerpt	Direct Quote from Manager	Developing a Narrative Thread
As a recent graduate, *Sofia is excited to be a design engineer* – a role she is passionate about and has experience in**.** *She starts her new position, and two weeks later, she gets some disappointing news—the project she was originally assigned to has been shut down. Her manager says,* "We're going have to find you a new job. We don't know what it's going be... Sorry, your product is going away. *We're really glad you're here. Just hold tight. Here's some training, we have to figure out where we're going."*	*So we had hired in November of last year, an engineer, mid-career probably about 10 years of experience, to come in as a design engineer on a specific project. The project that we had previously mentioned was shut down. We hired her. She joins in December, two weeks later, we decided to shut down the project. So we told her, "Well, we're really glad you're here. Just hold tight. Here's some training, let's, we gotta figure out where we're going." (Manager 1)* So I was a leader and here I am delivering this news that, "We're gonna have to find you a new job. We don't know what it's gonna be. Um, sorry, your product is going way." (Manager 2)	Each of the three excerpts focused on an engineer at a different career stage (late, mid, or early). I chose to use the mid-career design engineer example with the early career context. I combined the dialogue from the two scenarios and summarized the context.
The role is related to her capstone project, so she feels she has relevant experience to contribute.	**the option of just being 100% focused on his PhD [work] was no longer an option, it's an exciting part because I'm excited, I'm excited about this technology. And he just literally wanted to , go down that path, So they were phenomenal, they knew the computation, the architecture, the mathematics, all behind it, and they were experts. (Manager 3)**	The manager talks about a late- career Ph.D. hire that is focused on a technical niche that they are very passionate about. I included this element of being excited about the role but softened it to be a capstone rather than the work of a full dissertation or career.
Sofia's first reactions are loss, fear, and frustration. Sofia has some mentors at the company that she can talk to, and she expresses her concerns: What's going on? What does it mean? What's going to happen? How will it work out? She starts to understand that shutting down the	Her first reaction was upset, loss. I would probably do . . . I mean, I don't want to describe her emotions 'cause I'm not her, but if I was interpreting them, it was loss, frustration, and fear, um, was probably her first reaction. Thankfully by that time I had built up enough of a relationship with her to, to talk through with her.	I summarized this quote.

Table 5

Composite Narrative Example (Continued)

project is the right decision for both the team and the business.	She had some other good coaches and mentors. So I think a good coach and mentor was also important in that situation that was outside of their leader. . . . I think a key aspect of her being able to be adaptable was her other mentors that she had in the organization that she could go to and say, "Hey, here's what's going on? What does it mean? What's gonna happen? How does that, how does that work?" So I think that initial reaction was that fear and that loss. And then as she worked through it, it was, "Okay, I understand it's the right decision for the team. It's the right decision for the business. I'm gonna be okay." (Manager 2)	
A few days later, Sofia gets an update, "All right, you're going to be on this new team and be focused on a different product. So, we know this is not necessarily what we hired you for, but it's similar ... similar skillset, similar role, but different projects." She knows she is going to have to learn some new skills to work in this new role. *The transition is not happening quickly—it is projected to take over a month*! So, she takes the time to start learning. She finds small projects she can take on and tries to learn as much as she can. She really takes this new project as an opportunity to learn, broaden her network, get to know more people, and make connections within the organization. She successfully transitions into her new role. *She is very open to being able to work on different projects and is having success in this new area. However, as she continues to learn and contribute more,*	*So we know this is not necessarily what we hired you for, but it's similar. So similar skillset, similar role, um, but different projects." She was very open to being able to work on a different project, very adaptable, and even buried on a level of managing some of the early efforts from a project management standpoint. (Manager 1)* She did. She was coming from, um, uh, she was coming from [other company], and they use probably, it's not probably anymore Creo, um, and we use SolidWorks. So she had to learn a new design tool. So it wasn't that she didn't have the technical skills, but she didn't have it in that system. So, learning the new system. So she also was spending a lot of time just getting up to speed on SolidWorks. (Manager 2) So she really took it as an opportunity to learn, and broaden her network, and get to know more people, and make connections with inside the organization. (Manager 2)	I summarized the activities mentioned of learning new skills, broadening networks, getting to know more people, and making connections within the organization, as well as the successful transition into the new role. I also added details about the time it took mentioned in the quote by Manager 1 and the direct quote regarding not necessarily wanting to continue in the new role to which the new hire had been reassigned.

Table 5

Composite Narrative Example (Continued)

she realizes, 'This isn't necessarily where I want to be.' Sofia still wants to work on design related to the original project that she was hired for, and she starts to talk to her manager about her career desires.	*And she was able to complete her work on the team and transition into another team from what I read, everything I've heard quite successfully.* *I think probably the biggest challenge was the amount of time that it took for that transition to happen. We were talking, it was like the course of three, four months. It was a long time by most standards for something that would have happened, because there was just other changes that were going on that prevented it. The business was working as fast as they could, but unfortunately it took longer than anticipated. (Manager 1)* *but she was more than willing to like, "Hey, I can do this. I can pitch in if that's what you need." So for short time did it, and then identify like, "This isn't necessarily where I wanna be." (Manager 1)*	
Sofia's manager tells her, **"You [have to] look at what are the other areas that excite you [so] that you can leverage your competency, your energy, and your passion, and [we can] look at where [we can] move you."**	**So it was very hard for him. So I told him, "Okay, listen, you gotta look at what are the other areas that excite you that you can leverage your competency, your energy, and your passion, and peripherally kind of look at where can we, move you to, right?" (Manager 3)**	This is a paraphrase of the manager's direct quote.
Sofia and her manager work together to assign her to tasks that better match her skill sets and career desires in alignment with what the business needs, figuring out a solution that suits everybody.	*So as we, we learned that and her desires in her career, we arranged a few other pieces of the work, to, to better match her skillsets and her desires with what the business needed. . . . And we worked together to figure out how to get her in a spot that was best suited for everybody. (Manager 1)*	This is a paraphrase of the manager's direct quote.

Figure 1

Final Composite Narrative

So, we know this is not necessarily what we hired you for…

As a recent graduate, *Sofia is excited to be a design engineer* – a role she is passionate about and has experience in**. The role is related to her capstone project, so she feels she has relevant experience to contribute.** *She starts her new position, and two weeks later, she gets some disappointing news—the project she was originally assigned to has been shut down. Her manager says,*

> "We're going have to find you a new job. We don't know what it's going be... Sorry, your product is going away. *We're really glad you're here. Just hold tight. Here's some training, we have to figure out where we're going."*

Sofia's first reactions are loss, fear, and frustration. Sofia has some mentors at the company that she can talk to, and she expresses her concerns: What's going on? What does it mean? What's going to happen? How will it work out? She starts to understand that shutting down the project is the right decision for both the team and the business. *A few days later, she gets an update.*

> *"All right, you're going to be on this new team and be focused on a different product. So, we know this is not necessarily what we hired you for, but it's similar... similar skillset, similar role, but different projects."*

She knows she is going to have to learn some new skills to work in this new role. *The transition is not happening quickly—it is projected to take over a month!* So, she takes the time to start learning. She finds small projects she can take on and tries to learn as much as she can. She really takes this new project as an opportunity to learn, broaden her network, get to know more people, and make connections within the organization. She successfully transitions into her new role.

Sofia is very open to being able to work on different projects and is having success in this new area. However, as she continues to learn and contribute more, she realizes, "This isn't necessarily where I want to be." Sofia still wants to work on design related to the original project that she was hired for, and she starts to talk to her manager about her career desires. Her manager tells her,

> **"You have to look at what are the other areas that excite you so that you can leverage your competency, your energy and your passion, and we can look at where we can move you."**

Sofia and her manager work together to assign her to tasks that better match her skill sets and career desires in alignment with what the business needs, figuring out a solution that suits everybody.

Limitations

The composite narratives have some limitations. First, they rely on the researcher's judgment to develop the narrative (Willis, 2019). Some scholars have expressed concerns regarding the validity and rigor of this approach because the process can seem opaque, without a clear connection between the original data and the finished product. In response, Willis (2019) and Johnston (2021) specifically address reviews questioning their methods by outlining the development of their composite narratives in their respective papers. This dissertation similarly mapped out the development of a composite narrative in detail, providing transparency into the process.

Second, composite narratives in the literature tend to be first-person accounts (Creese et al., 2021; Johnston et al., 2021; Porter & Byrd, 2021; Willis, 2019). Even if the composite narratives are presented in the third person (Willis, 2019), the direct quotes still tend to be presented in the first person. The composite narratives created in this research do not necessarily have this type of richness because they are secondhand accounts told by the managers about their supervisees. This can be seen as a limitation, especially when managers describe what they believe their supervisee was thinking rather than just describing their behavior – these are the managers' hypotheses based on what they observed, and only the individual being described knows what exactly they were thinking. However, in many cases, managers may have provided broader, more detailed accounts of the situations faced by the engineers they supervised due to their unique vantage points as more senior members within their companies. The critical incident technique was also originally developed (partly) to capture supervisors' observations of their direct reports (Flanagan, 1954), which was the approach taken in this data collection. The stories are still powerful in provoking thought and understanding about the types of scenarios engineers face, which was the desired intent.

Classroom Intervention

Research Site

This data was collected from a large, public, predominately white-serving institution (PWI) in the southern United States, where female enrollment in engineering is approximately 22%. The classroom intervention was conducted across three course sections of an introduction to engineering design course for first-year engineering students, totaling 149 participants. The course is required for all engineering students and requires students to work in teams. The intervention was conducted with the researcher as a guest speaker in each section.

Intervention Design and Deployment

The goal of this intervention was to pilot a scenario-based classroom intervention to increase student awareness of adaptability as an important skill to have in the engineering workplace. The lesson plan for this intervention was developed with feedback from the researcher's dissertation committee, comprised of engineering education professors. The intervention in all three class sections occurred on the same day at the end of the Fall 2021 semester. At this point in the semester, students were reflecting on their time working in teams during the course and preparing for final class presentations the following week. A PowerPoint presentation (Appendix D) was prepared to provide students with a general overview of the intervention and guide them through the scenario-based activity. The intervention in each section followed the same format, as follows:

1) Students were asked to write down their perceptions of engineering adaptability.
2) The researcher led students through a structured discussion of two scenarios based on two of the composite narratives (see Table 6 for scenarios). During each discussion, students were presented with initial information about the scenario and asked to write down what they would do in that situation. The students were then given additional information about the scenario to further probe their thinking and expand on their initial responses. They were once again asked what they would do in the situation after receiving the additional information. The

researcher concluded the scenario by walking students through what managers actually described as having happened in the scenario.

3) Students were asked to write down their perceptions of engineering adaptability again.
4) Students then were given a presentation on the different dimensions of adaptability that emerged from the interviews with engineering managers and were instructed to reflect on whether their perceptions of adaptability had changed after the class session.

For the first scenario related to Interpersonal Adaptability, the additional information provided was that the part supplier, confronted with the knowledge that their part is no longer meeting specification, insists that there has been no change in their manufacturing process. For the second scenario related to Dealing with Uncertain and Unpredictable Situations, the additional information provided was that, after being reassigned to a different role, the engineer realizes that they may not be as well suited for their new role as the one they were initially hired for.

Scenarios Presented

An informal practice session was conducted to choose the scenarios for the intervention during the Fall 2021 semester. This session consisted of sharing multiple scenarios with an undergraduate engineering student, a graduate engineering student, and an engineering professor. Each participant read and discussed each scenario with me, touching upon their perception of what the scenario meant and how they would respond. Two scenarios involving *Interpersonal Adaptability* and *Dealing with an Uncertain and Unpredictable Situation* led to more fruitful discussions that also touched on other dimensions of adaptability. For this reason, these two scenarios were chosen as Scenario 1 and Scenario 2, respectively, for the intervention with students. The scenarios are shown in Table 6, along with the additional context provided to the students during the discussion of the scenario and what managers described as the resolution to the real-life situation on which the scenario was based.

Table 6

Classroom Activity Scenarios

Scenario	**Additional Context**	**Resolution**
Scenario 1 Dimension: Interpersonal Adaptability A supplier for a key part of your product is no longer meeting specification. The part is no longer the correct size, and it crucially impacts your design. The supplier had been meeting specifications previously. Your engineering team has tasked you with communicating with the supplier to address this issue.	1. The supplier claims nothing in their process has changed. 2. You travel to the site to learn more.	In this case, the supplier did not make a change—the engineering team had made their requirements more stringent. They worked with the supplier to meet the updated specification. In their communication with the supplier, they were open and did not cast blame.
Scenario 2 Dimension: Dealing with Uncertain and Unpredictable Situations You just got an engineering job. The job is related to an engineering project you did in school, so you are excited to bring your experience to the project. Two weeks after your start, the project you were supposed to work on is shut down. Your manager tells you that you will be working on a new project. You realize that this project requires you to apply your skills in a way you never have before—you have experience in developing software, but you have never programmed hardware as this project requires.	1. You learn the new skills, and what you thought might be a temporary project is extended. 2. After some time you realize you would rather be working on something related to what you were originally hired for.	In this case, the new engineer is open to the new project and eager to learn about the new project and do so. However, they also articulate their original interests and values to get moved to a relevant project eventually. The engineer is able to adjust during the uncertainty in their role, and then communicate effectively with their manager to find a position that better aligns with their core skills and interests.

Data Collection

Data collection was conducted during the in-class activity in the form of written student responses using Pear Deck, a presentation tool that allows for interactive questions to be asked and answers to be collected within Google Slides. Pear Deck assigned each student a random animal pseudonym so that no identifiable information was handled. These animal pseudonyms were replaced with gender neutral names prior to the analysis of the data. A total of 149 students consented to and participated in the activity. Some students who were not present in class watched a recorded version of the activity and still completed the reflection, resulting in a sample size of 158 students for that portion of the study. Table 7 presents the questions asked at each step of the classroom intervention.

After each of the three sessions, the researcher wrote a memo to capture their perceptions of the class context and student engagement. For the second session, the order of the scenarios was intentionally switched to determine if the order in which the scenarios was presented influenced the ways in which students responded. The memos helped capture the researcher's impressions of this effect and other differences between sections.

Table 7

Written Response Questions from Classroom Intervention

Question Asked	Time When Question Was Asked
What is adaptability in the engineering field?	During Classroom Activity (~4 minutes)
Scenario 1: A supplier for a key part of your product is no longer meeting specification. The part is no longer the correct size, and it crucially impacts your design. The supplier had been meeting specifications previously. Your engineering team has tasked you with communicating with the supplier to address the issue. Question (Before and After Additional Context): What are your next steps and why?	During Classroom Activity (~20 minutes)
Scenario 2: You just got an engineering job. The job is related to an engineering project you did in school, so you are excited to bring your experience to the project. Two weeks after your start, the project you were supposed to work on is shut down. Your manager tells you that you will be working on a new project. You realize that this project requires you to apply your skills in a way you never have before—you have experience in developing software, but you have never programmed hardware as this project requires. Question (Before and After Additional Context): What are your next steps and why?	During Classroom Activity (~20 minutes)
What is adaptability in the engineering field? (Has your answer changed?)	During Classroom Activity (~4 minutes)
How has your understanding of adaptability changed (if at all) after learning about it in class? Why and/or in what ways do you think adaptability is an important skill to the engineering workplace after learning about it in class?	Post-Activity and Presentation Reflection (~10 minutes)

Data Analysis

Students' responses to the in-class activity prompts were exported to Microsoft Excel and cleaned. A hybrid deductive-inductive thematic analysis approach (Fereday & Muir-Chochrane, 2006) with multiple coding cycles was used to analyze responses related to defining adaptability in the engineering field, mirroring the process used to analyze the engineering manager interview data. The first cycle involved open coding students' responses and generating codes related to their conceptualizations of adaptability (Saldaña, 2013). The second round of coding was completed using a more deductive analysis in which each transcript was read and coded for statements related to the same codes identified in the interviews with engineering managers (refer to Table 3). The initial codes were then upcycled, as appropriate, into overarching codes. Several student definitions contained multiple statements related to adaptability and, therefore, were assigned multiple codes. A content analysis (Anderson, 2007) was then used to compare student definitions of adaptability before and after the activity. Notably, students who reported "no change" in their definition of adaptability after the intervention were assigned the same codes for their post-activity definition of adaptability as they were for their pre-activity definition.

To analyze the written responses students shared regarding how they would respond to each scenario, a thematic analysis approach (Saldana, 2013) with multiple cycles of coding was used. The first cycle involved the open coding of student responses and generated many initial codes related to proposed actions (Saldaña, 2013). These actions were then upcycled into related codes, which were, in turn, applied to the data in a second round of coding. A content analysis (Anderson, 2007) was then again used to tabulate the number of times each code appeared in the data.

The students' post-activity reflection responses were also analyzed using a thematic analysis. There were two cycles of coding. First cycle coding was done on 15 reflections to develop an initial code list using concept coding (Saldaña, 2013). Then second cycle coding with this initial coding list was done on 15 more reflections, with the addition of pattern coding (Saldaña, 2013). Memos were written to capture the overarching themes in the data based on these cycles of coding, and then the final code list was developed with some codes being upcycled into broader theme categories. The final list was used to code the remaining reflections, and any deviations were noted. There were no additional codes added, but outliers in the data were highlighted for discussion in the results chapter.

Lastly, memo content from the day of the intervention was summarized to provide insights related to logistics and observations for each section. All three memos were read, reflected on, and summarized.

Limitations

A formal pre- or post-survey evaluation was intentionally not implemented in this pilot, as it was not expected that a concept like adaptability could be effectively taught in its entirety within a single class session. Although "wise" interventions in psychology have been reported to have significant impact in similarly short time frames (Walton & Wilson, 2018), crafting such an intervention requires a focus on psychological principles that are very well defined, as well as a pre-existing understanding of what may be challenging for participants about the concept. Adaptability is a complex construct involving many dimensions, and previous studies have shown that adaptability in one dimension does not imply adaptability in another dimension (Walker, 2015), making it difficult to know a priori on which aspects of adaptability students would most benefit from an intervention. Thus, while data from this pilot can begin to reveal how the concept of adaptability can be taught to students, a longitudinal study targeting each individual dimension of adaptability would be necessary to confirm whether the intervention helped students enhance their adaptability long-term.

Lastly, this study was conducted during the COVID-19 pandemic. Classes had resumed in-person, but everyone in the classroom wore face masks, which could have impacted student engagement and interaction with me and each other.

CHAPTER 4

DATA ANALYSIS AND FINDINGS

Overview

This chapter consists of three subsections that share findings from each part of this dissertation. The first subsection shares findings from the qualitative critical incident interviews with engineering managers. Six dimensions of adaptability were identified: Creative Problem Solving; Interpersonal Adaptability; Handling Work Stress; Dealing with Uncertain and Unpredictable Situations; Learning New Tasks, Technologies, and Procedures; and Cultural Adaptability. Further, contextual influences (adaptability balance and context) and personal influences (self-awareness and specific types of experiences) were identified. The second subsection shares composite narratives developed from the critical incidents identified by engineering managers. These composite narratives provide real examples of engineering adaptability in the workforce and show how dimensions of adaptability interact. The third subsection shares results from the classroom intervention during which students engaged with two scenarios based on two of the composite narratives. After the intervention, many students' definitions of adaptability became more multi-dimensional and reflective of the adaptability dimensions emphasized in the scenarios (Interpersonal Adaptability and Dealing with Uncertain and Unpredictable Situations). Some students' definitions also included elements of adaptability context and balance after the intervention. Further, students reported a better understanding of engineering work, an expanded definition of adaptability, greater delineation of adaptability, increased self-awareness, an appreciation for adaptability balance, and enhanced feelings of job preparation in their post-activity reflections.

Understanding Adaptability from Engineering Manager Interviews

Engineering managers shared critical incidents related to six dimensions of adaptability in their interviews: Creative Problem Solving; Interpersonal Adaptability; Handling Work Stress; Dealing with Uncertain and Unpredictable Situations; Learning New Tasks, Technologies, and Procedures; and Cultural Adaptability.

While all six dimensions map to Pulakos et al.'s (2000) eight dimensions of adaptive performance, only the first five map to those most associated with scientific and technical occupations (NASEM, 2018). The sixth dimension, Cultural Adaptability, was also found to be important to engineers as teams continue to become more global and engineering workplaces continue to exclude many. Notably, Cultural Adaptability as defined by engineering managers differed from Pulakos et al.'s definition of cultural adaptability in that engineering managers tended to focus on inclusion and understanding rather than compliance and adjustment, shifting responsibility for cultural adaptability to everyone, as opposed to centering any particular group to which others must assimilate. Engineering managers also discussed the importance of Knowledge Transfer, the ability to translate knowledge and skills from one context to another (e.g., from school to work), as part of Learning New Tasks, Technologies, and Procedures. Pulakos et al.'s other two adaptability dimensions, physically oriented adaptability and handling emergencies, were not emphasized by the managers at all.

In addition, managers recognized the influence of contextual factors on adaptability, including the need to adapt differently in different contexts (Adaptability Context) as well as whether and to what extent to adapt at all (Adaptability Balance), depending on the context. They also described the influence of personal factors on adaptability, namely, having had Specific Types of Experiences and Self-Awareness. This chapter further explores each dimension of and influence on adaptability in more depth.

Dimensions of Adaptability

Creative Problem Solving

All 17 engineering managers interviewed named creative problem solving as one way adaptability appears in the context of engineering work. According to these managers, creative problem solving comprises two distinct attitudes: (1) recognition that there can be multiple solutions to a problem, and (2) willingness to try various, sometimes unconventional, approaches to solving a problem until finding one that works. Manager 1 described these two ideas as follows:

> I think there's oftentimes adaptability in approach because there's often many methods that will solve a problem. And people tend to gravitate toward approaches that they used in the past and that they're familiar with, but [those approaches are] not always the best approach. I think there's a certain amount of being sensitive to the fact that other people solve similar problems in different ways and then trying to adapt your approach over time to use best practices done by other people and yourself. So, to not be afraid to abandon an approach you've used in the past if you notice another approach that's better. I think those are probably the main engineering adaptability kind of perspectives to have. (Manager 1, Midsize Medical Device Company).

In their quote, Manager 1 called out the importance of exploring solutions outside of those that an engineer might be most familiar with based on their own experiences and abandoning existing approaches that might not be working optimally to embrace something new. Often, this includes learning and adopting best practices from other people to solve problems effectively. Multiple solutions may work, but engineers can determine the most optimal solution by keeping an open mind and trying different approaches.

Further, some engineering managers who mentioned creative problem-solving noted that it requires the ability to synthesize large amounts of information and opinions to determine the root problem and different possible solutions:

> I think it's…the ability to discern a tremendous amount of information and begin to narrow it down…into action … the ability to take a look and hear all of the

> different opinions and then … begin to drive down into what some of the possibilities are. Yeah, I think those are the really good engineers … the good engineers, you know, can take a lot of information, distill it down to…two or three actionable items, right, and quickly get to the root of a problem. (Manager 10, Large Semi-conductor Company)

Manager 10 emphasized that engineers will be given significant data that they must interpret and put into action and, as Manager 1 also mentioned, they must consider all the information and approaches available to them before distilling this information down to solve the problem at hand. This requires that an engineer exhibits adaptable behavior in their openness to the data presented to them (i.e., all data as valid data) and their approach to interpreting the data.

Interpersonal Adaptability

All 17 managers interviewed described interpersonal adaptability, including the ability to effectively collaborate with colleagues and clearly communicate ideas, as critical to engineering work. With teamwork being so common in engineering, being able to work well on teams with other people was considered very important by the managers. Generally speaking, engineers are required to be open-minded and flexible during their communications with coworkers, managers, and people outside their organization, such as customers and suppliers. This means communicating to understand, asking questions, and changing communication styles as appropriate for different audiences. Manager 10 relayed an example of this communication, in which one of their engineering supervisees needed to keep an open mind, try to understand the problem, and find a solution when facing a misunderstanding with a supplier:

> You have to be open-minded, you have to be able to ask all the questions, listen to the answers to guide the people through the problem. Whenever you're working with anyone, actually, but a supplier in this case, they're going to be defensive coming in, and they're going to say, "There's nothing wrong here, nothing changed, it has to be something else." Being able to come in and hear that … not make the team feel like they're getting blamed for the problem, but [instead create] an environment where, "We're just here to solve the problem. Let's figure

> out what actually is happening, and then we'll come up with a solution without somebody getting the blame for making [a] mistake." (Manager 10, Large Semi-Conductor Company)

In this example shared by Manager 10, the engineer described had to communicate in an open-minded and understanding way to prevent the supplier from feeling like they were being blamed for a mistake. Manager 10 emphasized that creating and maintaining an adaptable and open communication style is important at all times on the job, especially when trying to resolve an issue.

Nearly half of managers also mentioned the need for engineers to communicate flexibly with those outside their own teams, functional units, organizations, and disciplines. This may mean that an engineer can comfortably and effectively ask questions to another individual in an area outside of their expertise. Manager 6 provided an example of this cross-channel flexibility, stating the following:

> He would also reach out to people and even cross-functional teams and people in [Other Company Site]. It didn't bother him that he didn't know something, right? He didn't shut down because he didn't know something and wasn't afraid to ask questions of more experienced people or people even outside of our group. (Manager 6, Midsize Electronics Company)

Approximately a quarter of managers also discussed how engineers need to be comfortable regularly adjusting their communication style to persuade different groups of colleagues to listen to them and their perspectives. These adjustments in interpersonal communications were described as a key adaptability component, as Manager 16 attested:

> There's this adaptability [in terms of] how you're conveying something, in terms of from the outside looking in. Like, bringing in that outside perspective has to resonate with the team in a different way than just being, like, "Hey, that's not right, and I know it's not right because we had that learning at this other company . . . 50 years ago, whatever it is." So, there's this adaptability that's, that's not even like the engineering aspect, it's the ability to convey different engineering thoughts. (Manager 16. Mid-Size Medical Device Company)

Manager 16 described that effective interpersonal adaptability requires that an engineer build an understanding of their colleagues through listening, as also mentioned by Manager 10, so that they can communicate an idea or perspective in a way that will resonate with their colleagues and afford them buy-in.

Manager 12 further described interpersonal adaptability as including others in discussion and really listening to their ideas without ego, even when disagreement occurs. They expressed that engineers should be open to receiving feedback in different contexts and from different stakeholders to determine the optimal solution for their problem. Manager 12 relayed their own experiences with this kind of interpersonal adaptability, stating:

> I'm huge on inclusivity because…I learned the hard way…when I was a design engineer. I hated people telling me my design was wrong or there was something broken and I would look for ways to [say], you know, "Yeah, maybe it was my fault," [and] fix ... it a different way. The ability to kind of take a look and hear all of the different opinions and then, you know, separate the personal, almost the ego, if you will, and begin to drive down into what some of these possibilities are. (Manager 12, Very Large Semi-Conductor Company)

In this quote, Manager 12 explained that an adaptable engineer is open to different possibilities and actively listens to others, separating their ego and their own beliefs from what may actually be the best course of action to move forward. Manager 12 also described how they became more adaptable over time by adjusting their own communication and listening skills to be more inclusive.

Handling Work Stress

Just over half of engineering managers described that the engineers on their teams must handle work stress, often adapting to varying workloads. They discussed how projects can be on one- to two-year timelines, depending on the contract with the customer, with increased travel and work demands, especially in the electronics industry. In these cases, engineers may have to adapt to being very busy at certain times of the year and not busy at other times, as Manager 4 explained:

> Certainly large workloads [are] pretty normal. I'd say that's seen as normal because a lot of these tend to be . . . maybe one- or two-year long projects, and so there are periods during the long projects where the workload is very high and it requires a lot of extra hours, and . . . you have to be adaptable timewise to get things done and meet deadlines. Somebody I work with—he's a designer. We were working with a fairly large cellphone customer, and part of his job became managing the interaction for the customer, and that customer was very demanding. And it's very stressful, he had to travel a lot, which wasn't normal for him. He had to deal with all of these technical issues with the customer, and, it looked to be very stressful. (Manager 4, Mid-Size Electronics Company)

Manager 4 explained the need for engineers to adapt how they manage their time, especially when working with demanding customers. This may require troubleshooting technical issues or even travel to the customer, both of which Manager 4 described as potentially time-consuming and stressful.

Similarly, Manager 17 mentioned that engineers may need to adapt to constant fluctuation in the number of hours worked from week to week:

> That's another part that I've seen, in terms of adaptability to work. How the work is, even though we all say, a 40-hour constant workweek, it never really works out [that way]. And I've never seen, in my life, it working out like that. So that's another piece of adapting, especially when you come from college and you're coming to work, and you hear, "Now a 40-hour work week." It may not be like that. It may be more during certain time period[s], and it may be much less during other time periods. You need to adjust. (Manager 17, Mid-Size Electronics Company)

Manager 17 remarked that while students coming from college may believe that they will have a consistent 40-hour work week, that is not the reality in any job they have worked as an engineer. They emphasize that it is, therefore, very important that engineers can effectively manage their time and prioritize tasks so that they can adapt to the varying workloads and schedules.

In addition, approximately a third of managers specifically reported that engineers are expected to stay calm, not become overwhelmed, and manage stress effectively, even despite large and busy workloads. Manager 5 mentioned that some engineers struggle with adapting to large workloads, and described a situation in which they needed to limit an engineer's workload, because the engineer would become physically ill and unable to work due to difficulty handling the extra pressure:

> As an individual contributor, he is quite successful, right, but . . . when you put too much of a workload, either too many tasks running in parallel [or] too short of a schedule, then he, he can't handle it. Physically he can't handle it. He can't even come to work, he just gets physically ill. That's a specific employee that we know that we have to manage the workload that we give him. That he's a great employee at a certain level of workload but once he gets beyond that, he's not a good employee. He just can't function. (Manager 5, Mid-Size Electronics Company)

Notably, in this example, the engineering manager also described the adaptability in their own management style – a kind of interpersonal adaptability. They recognize that all employees are different and that they need to be mindful about the workload they assign to each employee if the employee is to be successful.

Dealing with Uncertain and Unpredictable Situations

All 17 engineering managers explained the need for engineers at their companies to regularly act quickly, despite ambiguity and uncertainty about the complete situation. Manager 2 described this need to switch gears and make decisions based on new information or shifting priorities, as follows:

> In the context of engineering work, [adaptability] really means the ability to switch gears based on changing priorities or based on new information. We're constantly getting new information, we're making decisions every day, and those decisions are [a] trickle-down effect. So, I think adaptability is being able to adjust, based on a new context and that new information, whether [it's] that specific tolerance stack-up that you're doing, or the design of experiments that you're running, or just how you're interacting with the teams. (Manager 2, Mid-Size Medical Device Company)

Managers who discussed dealing with uncertain and unpredictable situations named a variety of unexpected obstacles engineers might face on the job, from technical challenges to a loss of resources or funding to even design failures. Manager 1 talked about these situations in the following quote, emphasizing the importance of engineers being able to navigate them successfully:

> What I saw it as is the ability to navigate change; you have a plan, something unexpected happens, so you have to make a change. That flexibility, or moldability to a path that ... is, for example, this wide, you don't have to walk in the middle. You can probably navigate around that path to get to the same place, but there's going be obstacles in your way, so how you adapt to, an obstacle where you no longer have funding, or you no longer have a resource, or you no longer have . . . this technical uncertainty popped out there. Like, "I didn't know it could fail that way." So, you have a plan and maybe the device failed, and you just... You're like, "Whoa. I was not expecting that at all." I could see some engineers just getting stopped in their tracks and not knowing what next steps to take (Manager 1, Mid-Size Medical Device Company)

Further, engineers may have to make decisions based on limited information. Manager 16 illustrates this point in describing how engineering problems are not always fixed, and there may be a need to make educated guesses and be prepared to pivot their designs, approaches, and decisions if they are not correct:

> "And I think probably the other one is the ability to deal with a high degree of ambiguity. There are not fixed answers, there are not fixed questions, there are sometimes not even fixed problems. You have to be able to take the data at hand, you have to be able to know what data is important to you based on what you have, you have to make conclusions off from that data, which may only give you a piece of the total picture... you have to make lightning quick decisions based on what you have, and it's hard to say this, but it's true, they have to be correct, right? So yeah, you're making educated engineering guesses, but you're using the data to say, "I'm going to be really close and if I'm not there I've got to be able to pivot really quickly." (Manager 16, Mid-Size Medical Device Company)

Manager 16 shared that even though an engineer's work is defined by ambiguity, with constantly changing questions and problems, they must still do their due diligence to reach the best solution possible, especially in a field such as medical devices, where engineers' decisions can have a direct impact on people's health.

Learning New Tasks, Technologies, and Procedures

All 17 engineering managers mentioned that engineers must continuously learn new tasks, technologies, and procedures to keep up with the changing needs of their job week to week. Further, what engineers must learn may not always be a part of their formal training, and therefore, they must take initiative to ask questions and learn new skills related to what they need to know. Manager 6 described this sentiment, saying:

> You have to be adaptable in maybe that thing that you're working on isn't something that you got trained to do. So, you have to come up to speed on it, work through it and do that, and then maybe the next day you have something else that you have to do. There's an adaptability in the tasks that you have to do. And some of those are maybe something you really enjoy, some of it is maybe not, but you still have to get those things done. You have to be an adaptable learner where you can learn or ask questions or figure out how to do the tasks that you're given. (Manager 6, Mid-Size Electronics Company)

Some managers also discussed the need for engineers to adapt quickly to new productivity tools that are relevant and effective to their work. Manager 14 spoke of this need as follows:

> The fundamental physics that underl[ie] it do[n't] change, but people have to basically learn on the job and adapt. And that's not just in the understanding of the particular part of the semiconductors for [Midsize Semiconductor Company]. But we use productivity tools; software is a really big thing. A lot of software we can buy can't do things that will do what we want, so we do have to develop them. As new tools and new languages come out, we have to keep moving to adopt the best of those. And I have certainly seen over 30 years that has completely changed. . . . It's all of a sudden you see that the person next to you is using JMP or Python or is using some other analysis and capability, and to then to adapt to that. In general, what I'd say there is when you see something that someone's doing better, don't complain about it, and keep doing what you're doing. Use what they do. (Manager 14, Large Semiconductor Company)

Multiple engineering managers also specifically mentioned the importance of being able to apply theory to practice when learning new skills or adapting their academic skills to the work context. They referred to the book-oriented nature of engineering education and the need for engineers to know how to apply or transfer what they have learned to the job such that, for example, devices they created as simulations actually work when developed. Manager 6 elaborated on this sentiment, describing how important it is that engineers know how to practically apply and extend the equations they learned during school to real life:

> That's one of the keys that I would say [an] engineer would need to know is, not just the learning, but taking that learning and applying it to the tasks that you have. It's not just learning how to do a proof, it's using that proof to actually solve a real-world problem, get that answer, and then say, "Okay, hey, this kinda looks really novel and unique. I'm actually gonna take it a little bit farther and see if there's something interesting in here as well." It's following a trail of where the problem's going—and not just going, "Okay, I learned this formula to do this. Here's all the . . . variables that go into that equation, and I can solve [it]." (Manager 6, Mid-Size Electronics Company)

Similarly, Manager 8, mentioned cases in which engineers were able to learn a task but not able to apply it, exhibiting an absence of knowledge transfer:

> You have to be able to learn something, but then you have to do it. And I do see some people that can learn something very well and take it where they've learned it and tell you how, what they learned, but then they've never taken that and applied it to the thing that they have to actually do with it. So, they can learn it, but then they struggle with the application of that learning to do the thing that we needed to get done. (Manager 8, Very Large Semi-Conductor Company)

Cultural Adaptability

About a third of managers also noted the importance of cultural adaptability in multiple contexts, including working across teams and functions; working within company cultures and climates; and working globally, as teams within engineering companies have become much more global and multidisciplinary.

Manager 3 reflected on the global nature of the engineering field and called for greater cultural awareness and competency when communicating as an engineer with individuals around the world:

> I think that's so important, not just within your teams as you have more diverse engineering teams, but also within, when you talk about virtual teams and working with—if you work with someone in India or China or anywhere across the globe—being mindful of you as an engineer, how you communicate with them, and to be culturally aware. (Manager 3, Mid-Size Medical Device Company)

Manager 10 expanded on this idea, describing the need for culturally competent communication skills. As engineering teams become more global, they should make efforts to understand the norms and values within different cultures and communicate and work accordingly. For example, Manager 10 compared their observations of the ways that Asian engineers and American and Northern European engineers give feedback and conduct meetings, emphasizing the importance of cross-cultural communication and appreciation of differences:

> Communication is going to get more and more critical. Unfortunately, I think it's something that's less emphasized. All the teams that you're working with are going be global in nature. So, you need to be able to communicate with a variety of different cultures and understanding that not everybody speaks with the same degree of fluency. So, how do you change your communication skills, between, different cultures so that things work? … For example, in Asia, you need to be careful about how you criticize people, because you don't want anybody to lose face, which is a real thing [whereas] if you're talking to a Northern European, you're going to get a different reaction on a criticism. And, the responses you're going get may seem a little more blunt, for example, when that's just their way of interacting. So, understanding cultural differences and being able to communicate between cultures is something that I think is going to increase in requirement over time … [T]hose that can do that are going to be more successful … And the way you learn is that you go out with people, you talk to them, you still try to do it. I've always found that, when you start a call with your team or especially a new team, you try to find something of interest to discuss, right? So it's, how's the weather? You just had a holiday, what did you do? Uh, how's COVID, what's your area look like? You have to be able to build a common bond of some sort, and I've found that people that can't do that, especially Americans that immediately want to get to business, it doesn't, you just don't get where you need to go. (Manager 10, Large Semiconductor Company)

In this quote, Manager 10 mentioned the importance of respecting colleagues' norms by adjusting communication within different contexts, such as how feedback is expressed and received. They also recommended that engineers try to build connection with their colleagues to learn more about their norms and values and create a common bond, warning that not building connection or acknowledging these differences could have negative consequences.

Separately, Manager 3 remarked on the need for engineers to catch up to changes in the demographics of the engineering workforce, noting that engineers today are not all men, and that certain language should be retired to create more welcoming and inclusive environments for women:

> It is very important to be able to communicate while being very conscious of other cultures or just diversity in general. . . . [It is] especially important . . . as engineers, because there are some roles or some industries [that] previously used to have, predominantly, a specific type of demographic, right—it was like a typical male engineer. And that has changed so much in the past 30 years or so, that, I don't know if the . . . communication training, the awareness training has caught up to say that, "Hey, you might use words that are like very typical, or maybe have some sort of underlying tone of it being very typically male because you're in a male-dominated engineering group or something, and how do we be mindful of that?" (Manager 3, Mid-Size Medical Device Company)

Manager 3 expressed that the engineering workforce is becoming more diverse, and therefore, engineers should adapt their behaviors to create a more inclusive culture through their communication and tone. They talked specifically about how communication and awareness training has not entirely caught up with these changes, with some male-dominated engineering groups still using an underlying tone that is not inclusive to others.

Lastly, Manager 16 discussed that project teams, workplaces, and organizations each have different cultural values, and that engineers need to be aware and considerate of these values when working across boundaries:

> The culture in different companies [is] not all the same, right? What the company I'm with, what core values [the company has] may not be the same as. . . a competitor, right? Competitors may value the monetary KPIs more than the employee engagement. And so, I think a lot of times, when you bring in a lot of experience into an environment where it [the culture] acts totally different than the current environment, like where we are and where we work today, there's this adaptability piece. (Manager 16, Mid-size Medical Device Company)

As mentioned in previous manager quotes, engineers often work with other companies in many contexts (e.g., as customers or suppliers). Manager 16 explained that all these different organizations will have different cultures and values and that understanding these differences in norms will help engineers communicate and work with each of these stakeholders effectively. For example, Manager 16 specifically remarked that some competitor companies might focus more on key performance indicators than employee engagement, influencing their operations and priorities. An engineer matching their message and communication style to the other company's might be critical to getting their ideas heard and accepted.

Personal and Contextual Influences on Adaptability

In addition to identifying different dimensions of adaptability, managers also discussed personal and contextual factors that influenced engineers' adaptability. Examples of managers describing each of these factors are highlighted below.

Self-awareness

Nearly a third of managers discussed self-awareness as an important precursor to adaptable behavior. They mentioned that ideally engineers would possess self-awareness so that they can reflect on the bigger picture of how their work fits into the organization and adapt their behavior to meet deliverables accordingly. Manager 15 expressed this sentiment, describing self-awareness as foundational to adaptability, above other experiences, and skills:

> I don't think adaptability equals experience, equals skills, equals success. . . . I think what the adaptability for me is self-awareness. . . . You have to be self-aware and you have to be aware of the environment that you live in. You have to be aware of the scope of your work. (Manager 15, Very Large Semi-Conductor Company)

Manager 15 elaborated further on this idea by providing a scenario in which an engineer needed to assess the technological changes happening around them and adapt accordingly to keep their skills current and stay competitive:

> If you are, let's say an engineer in the automotive industry . . . you know how to design engines and how to design all these parts that require an automobile to function. Now, guess what? . . . We have self-driving cars, right? The automotive industry is going through a massive transition in terms of AI [artificial intelligence] coming into cars—the fuel, energy and all that. If you wanna be adaptable and grow in your career, then you can't just say, "Hey, I know how to build a so-and-so engine." You have to keep in track of, "Hey, where is this industry actually going? What are the new things I need to learn? What is the play of AI in this particular industry?"

Manager 15 expanded on the idea that, for an engineer to effectively adapt, they need to have self-awareness of their strengths (to have a foundation to start from), their values (to have intrinsic motivation to continue to learn more), and the changes occurring to their work environment (to know how to leverage their unique skills and values to stay relevant to their profession). Manager 15 described this self-awareness as follows:

> "Does that excite me or not?" And if it translates into, "I don't really care about software, I care about hardware," then, you know, what does that hardware evolution actually look like, right . . what's the evolution of the battery power? And, and all these different things. So, you have to constantly be aware of … what are the skills that you bring to the table? That's your foundation, right? You grow, and then you learn new things, new tool sets, new things, right? … But you also have to be aware of what environment you actually live in in order to make sure [you have] a holistic [view] and [that] you're stronger in this particular situation. (Manager 15, Very Large Semi-Conductor Company)

Additionally, Manager 12 highlighted the importance of individuals being aware of their strengths and weaknesses as a key to working in the collaborative environment. Due to the complexity of engineering problems, engineers must work in teams; being adaptable will require them to recognize the strengths they contribute to that team and the expertise they need to seek out to supplement their weaknesses, either in the form of new skills or other people. Manager 12 described this idea as follows:

> The problems are incredibly complex that we're working on, and you know, engineers that don't understand their strengths or haven't built relationships with people that complement their weaknesses are the ones that actually struggle a lot. You hear an expression—actually, my manager, as I was coming into management, one of the things they said is, "Hey, you're gonna get to a point where you can start to build your own staff. Surround yourself with people that are smarter than you." You hear that, it's like, "Ah, you know, everybody is

> smarter than me in some capacity." But that's not the point. The point is—you have weaknesses, right? Whether it's, you can't program management, you don't understand the software side or whatever, build your team around your weakness and that's gonna strengthen you up. (Manager 12, Very Large Semi-Conductor Company)

Recognizing that no one engineer is infallible, Manager 2 also discussed the need to possess self-awareness to learn from mistakes and know how to better adapt in the future, stating:

> [I think] the ability to reflect and learn from your mistakes also plays into your ability to be adaptable. Do you have enough self-awareness and self-governance to look back and say, "Hey, what I did five years ago, if I knew, then what I know now, I wouldn't have done it like that." I do that. I know some of my most trusted colleagues do that. They're like, "I wouldn't do it like that again," or, "Hey, here's what we learned. Here's how we could do it different next time. Here's what we would do better. Here's what we learned in the process. Don't repeat that mistake." So I think that's a key as well as are you willing to reflect and look for opportunities to do something different? (Manager 2, Midsize Medical Device Company)

Specific Kinds of Experiences

Nearly half of engineering managers interviewed also hypothesized that having had specific kinds of experiences could increase an engineer's adaptability. For example, Manager 16 described how having knowledge, even broad knowledge from other fields outside of engineering, was beneficial to adaptability in technical work:

> If you've got a broad background and ability to think through the fundamentals, that gives you some of that adaptability. Another part of it is experience. So, if you've solved a number of problems, you can draw from that experience to solve future problems. So it's again, adaptability. I equate it to breadth and breadth of understanding, breadth of experience. The other piece is those that are creative—you get the sense of creativity from whether it's musical, artistic—also seem to possess this broader ability to adapt, because a lot of what they're doing in their other activities is all about adaptability. So, they're just applying what they do in art and what they do in music to, then, what they're doing in the engineering world. So, I think it's that breadth of capability within a given individual and it's their exposure in those different areas and how they're using learning outside of the traditional engineering sense, which is very much book-oriented. (Manager 16, Mid-Sized Medical Device Company)

Manager 16 mentioned that having a breadth of experience in different areas meant that engineers had knowledge of other contexts (e.g., music) from which they could draw solutions to future problems, resulting in greater creativity and adaptability.

Manager 12 believed that engineers who had more cross-disciplinary and project types of experiences in school were bound to be more adaptable when entering the workforce because they had more experience working with ambiguous technical projects that could directly translate to their engineering work:

> I see schools that have those [cross-disciplinary] types of programs… And we talk about those…in interviews and wanting to know about those, if you had a senior design project or you had these group projects. Those folks I've definitely seen do much better [with] kind of the ambiguity and…adapting to the ambiguity and the evolving nature of…especially the high-tech [projects]…. than others who may not have had that exposure. (Manager 12, Very Large Semi-Conductor Company)

Similarly, Manager 8 saw participation in study abroad programs or experiences as contributing to an engineer's adaptability by exposing them to different mindsets and ways of learning beyond what they might typically experience in an engineering program:

> I think exchange programs overseas are…invaluable. I think getting a chance to study …with a different mindset, different way of learning … really provides that [adaptability] and provid[es] some flexibility within what are often very rigorous and structured engineering programs. So, I think [the] academic world has some stuff to offer. (Manager 8, Mid-Sized Electronic Company)

Adaptability Context

The interviews with engineering managers also revealed that how an engineer needs to adapt to the job can depend on various contexts, including their role type, functional unit, and career stage. Nearly three quarter of managers described these contexts at their companies. Regarding role type, Manager 13 expanded on this idea, differentiating between engineers who are more "scientific," i.e., specialists, and engineers who are more "pragmatic," i.e., generalists. Both types of engineers might exhibit adaptability. However, those in “scientific” roles might specialize in innovating new tools, techniques, and ways of doing research, whereas those in “pragmatic” roles might rotate through different parts of the organization, applying their general skills in myriad ways:

> But I think there’s also [a certain group] of engineers that I would consider [as] more scientists than engineers. [They] really enjoy what they do, very specialized, focused on a particular area. The adaptability that takes place on the scientist side of the scale is adaptability . . . to new technologies, new techniques, new ways of doing things, new software tools … that aspect of things. New ways of research. On the more pragmatic or practical side of engineering, there’s an adaptability to being a jack of all trades. Trying to understand how other parts of the organization work, what makes the customers tick, what, how do we learn and innovate and try new things. And that may be working as a product engineer for a while, and then working as a design engineer for a while, and then working as a test engineer for a while, and then maybe moving into marketing with a bent toward sales, so that level of excitement for people. Some people really enjoy that level of adaptability or change, and some people prefer to stay much more focused, in a particular area of technology. (Manager 13, Large Semiconductor Company)

As Manager 13 described, how an engineer adapts to the job can depend on their unit within their organization. For example, both research and development (R&D) and manufacturing engineers might be required to creatively problem solve, but doing so might mean eliminating design obstacles in the product development stage for R&D engineers and working around design obstacles in the commercialization stage for manufacturing engineers, as explained by Manager 3:

> If you’re early on in development and you’re already seeing problems, it’s probably a red flag that you’d want to have more of that curiosity mindset, and the further you get down … the more you might [want] to work around obstacles, as opposed to solving the obstacle … So, I have a very new product development mindset where if there’s a problem we have to fix it [because no one’s going to want to] fix it later. But once you hit commercial, creativity becomes, “How do I solve this without changing the design?” Or, “How do I solve this without affecting biocompatibility of the device?” Creativity could come up in different ways from an adaptability [standpoint] because I think if you’re in a different phase of a project, from an engineering perspective you may have to deal with change differently. (Manager 3, Mid-Size Medical Device Company)

Further, similar patterns emerged from the interviews regarding how adaptability might look different in early versus late-career engineers. More specifically, managers mentioned that adaptability in early-career engineers often focuses on building technical adaptability, such as learning new tasks, technologies, and procedures, whereas adaptability in late-career engineers who may be moving into management roles is more focused on interpersonal adaptability, such as leading others:

> The meaning of adaptability early in your career . . . may mean skills; later in your career, adaptability may mean how you position yourself, in terms of your soft [professional] skills. And ... the balance between, where you spend your time, right. And it's an ever-changing balance, as you grow up into, into the ladder, you may need to. . . start shifting the way you do things, right? (Manager 9, Very Large Semiconductor Company)

The engineering managers also mentioned greater social and contemporary contexts to which engineering organizations and individual employees must adapt moving forward. For example, at the time this research was being conducted, two different events were occurring in the United States – widespread protests against systemic racism, in the wake of George Floyd's murder, and the COVID-19 pandemic. Related to systemic oppression, more than half of all managers interviewed (nine of the 17) mentioned the need to foster greater diversity, equity, and inclusion within the engineering field, starting with the organization but also extending to changes in the behavior of individual engineers. These managers discussed their thoughts on the need to broaden participation, and specifically, the need to communicate to students that there are many different types of engineering roles that exist beyond those that may appear exclusive. Manager 10 and Manager 13 summarize these sentiments, respectively:

> It used to be all white men in engineering. It's still primarily male, and I think there's a problem with that. . . . It's been going on for a while. . . . Somehow broadening that I don't have an answer, but that—that needs to happen. (Manager 10, Large Semiconductor Company)

> Engineering is extremely diverse, there's a lot different types of roles, different ways of doing things. [Because everyone is doing the exact same things] in the first three years of engineering school …if you don't like one of [the courses in school], you think engineering is not for me. And I think we might be scaring away… people that have a ton to offer in a different way…I hope we can continue to find ways of communicating [that] to the young engineers. (Manager 13, Large Semiconductor Company)

Related to COVID-19, two managers acknowledged that engineers caring for young children while working remotely faced elevated challenges in managing childcare while school was conducted virtually and daycare was unavailable, and that working remotely appeared to be something to which engineers would need to adapt long-term, with Manager 14 and Manager 17 stating:

> What I [do not] have visibility into is [that] virtually all of the people in my organization, across the planet to—that I interact with a lot, do [not] live by themselves, they have families. And so, for most people, [the] main issues have been—particularly people that have children that are going to school, I think that is probably the biggest issue. It's people having to take care of their kids and then balancing time. (Manager 14, Large Semiconductor Company)

> I think [remote work] is here to stay. It won't be like where it is right now, but it'll be hybrid, some sort of hybrid. Maybe [a] couple of days in [the] office and, you know, [a] couple of days working from home, [and] whatnot. So, I think people just need to get used to that. (Manager 17, Mid-size Electronic Company)

At the same time, Manager 12 theorized that remote work may help some engineers that are typically quieter in meetings have a space where they feel more comfortable to speak up and voice their opinions, particularly women engineers on their team:

> It's interesting. . . . On the one hand, it feels like it makes inclusion a little bit easier, you know, with the digital stuff because I don't think people are—the focus is on the screen, not you, right? And so, I think in some cases that makes it a little bit easier for people to be a little more vocal. I have a couple engineers, architects, senior architects that are female, and it's really interesting. . . .When we're in the office, we would be in meetings, and they're very quiet, and then afterwards they'd always send something, "Oh, hey, I thought about this a little bit more." And they work that way, they need a little bit more time to think and stuff. So, I know that about these individuals, and they weren't, [very active] in a face-to-face meeting. What I've noticed with the COVID stuff is they're just there. I mean, they're like, "Oh, hey, you know, we should look at this, this and this." And it's almost like a confidence change, right? They're much more comfortable with,

> with this type of, of setup. I think we need to explore [this]. Male, female, it doesn't matter, but what types of tools we have that's working for people well, and we can see if there's a way that we can actually, you know, emphasize that a little bit more. Or use it a little bit more judiciously, with different teams or different individuals, where it brings out the best in them. So yeah, a little bit of adaptability for—on our part, I think we need to look at that. (Manager 12, Very Large Semi-Conductor Company)

Manager 12 reflected on how the way they conduct meetings could act as a catalyst or barrier to their engineers' adaptability and how virtual meetings could now be used to bring out the best in their employees in certain contexts. As the data show, COVID-19 brought an expanded definition for adaptability in the workplace, including a transition to working remotely. Meanwhile, the murder of George Floyd raised greater awareness of issues of systemic racism and inequity within the United States.

Adaptability Balance

Beyond the contexts to which engineers must adapt, seven engineering managers mentioned that there is a balance to being adaptable in general. In some cases, this balance refers to how much of a certain adaptive behavior an engineer engages in. For example, while asking questions on the job can be useful for gathering information, the intentions behind and way of asking these questions are important. As described by Manager 1, there is a difference between asking questions to understand the solution space for a problem and asking questions to identify a single right answer and eliminate any source of uncertainty:

> There [are] some [engineers] that are very inquisitive, and sometimes I think they're going for too much. Like, it's almost like trying to get to a level of certainty instead of just, "This is the direction I need to go." I think when you're dealing with ambiguity, trying to figure out a general direction, [in] engineering sometimes you have a very specific, "This is the direction I must go." But other times there is flex in how you get there, so I think when you ask questions in a way that leave[s] your options open, you tend to be more adaptable because you're not focused on a single path. (Manager 1, Mid-Size Medical Device Company)

In another example, Manager 13 communicated the need for engineers to balance (i.e., set boundaries on) the degree to which they try to adapt to and remedy problematic situations, recommending a “more assertive approach” in which they might choose to eliminate the problem altogether instead:

> With that said, I think there are situations where a much more assertive approach is necessary. There are bad situations in engineering … and difficult situations, and things that are going very poorly, and somebody needs to come in and turn things around. Thankfully we haven’t had that many situations like that within our team, but I think adaptability sometimes means coming in and cleaning house as well. (Manager 13, Very Large Semiconductor Company)

Manager 13 remarked that sometimes being adaptable means adopting the best solution to a problem rather than being accommodating per se, such as in unethical situations. In these situations, engineers must balance adaptive approaches and behaviors with pushing against the current norms, “cleaning house,” and making changes to ensure the best outcomes.

Along similar lines, Manager 4 discussed the need to balance working with technically competent but challenging coworkers, remarking that staying in such a toxic work environment would be undesirable:

> It’s not a secret, but a lot of people that are highly skilled, solving technical problems, can also be very difficult to work with on a personal level or. . . just socially very not easy to work with oftentimes. And so I’ve worked at companies where you just have some incredibly toxic personalities that go along with a good technical skillset. And even though that person can do things that a lot of other people can’t, they’re just so difficult to work with and interact with that you can’t build teams up around people like that because they just chase everybody away. People don’t [want to] have arguments daily about normal things that should just be conversations, and resolutions. So that’s very common in technical environments to have, just difficult people, kind of interwoven into the work environment that you just have to deal with. I’ll say abusive, emotionally abusive, mentally abusive managers, and, it’s just, there’s a lot of that out there. (Manager 4, Mid-Size Electronics Company)

Manager 4 described that this type of "balance" in adaptive behaviors may be necessary when an engineer must work with colleagues, or even managers, who may be abusive to them.

Lastly, Manger 15 discussed the importance of balance in the efforts of an employee and their organization to ensure the employee's success, emphasizing that the effort should be shared equally between both parties rather than depend on the employees' total assimilation:

> And, also the community, right? So, it's 50/50, right? It's [50 percent] how you show up ... and the other 50 [percent] you cannot deny the environment that [the organization] create[s] because interns cannot be successful, or any newcomers, forget about age, gender, anything, you cannot be successful until the environment gives you the opportunity, right? You can plant the most beautiful orchid or most beautiful plant, but if you don't nurture [it] and if you don't pour water...then it'll eventually die. (Manager 15, Very Large Semiconductor Company)

Manager 15 expressed that an engineer could not be expected to effectively adapt to the workplace without support and developmental opportunities from their organization, requiring equal efforts on the parts of the individual and their work environment.

General Perceptions of Adaptability by Engineering Managers

Overall, interpersonal adaptability behaviors were the most mentioned adaptability dimension in the interviews with engineering managers, underscoring the importance of developing these behaviors. A few managers believed that interpersonal adaptability and other "soft (professional) skills" could not be taught to engineers as easily as technical skills such as problem solving. This perception made interpersonal skills an especially important focus for engineering managers when hiring:

> When I'm interviewing somebody, what I'm looking for are the soft traits. I'm not really looking, you know, whether technically how skilled this person is. Of course, we ask technical questions, but even in those, what I look for is what the thought process a person may have. Right? But the soft skills are very important, because I cannot change soft skills. I cannot teach somebody how to

> communicate better. You know, how to be more adaptable [or how] to have an open mind . . . how to multi-task. I can't teach that to somebody. But I can teach somebody how, you know, analyze circuits. To me, it is just, you know, natural to people. You know, some people are humble, some aren't, you know? (Manager 17, Mid-Size Electronic Company)

Separately, some managers found it challenging to describe adaptability in general or mentioned that it contained multiple dimensions. This finding helps illustrate the need for a more common definition of adaptability in the engineering workplace.

Discussion of Manager Interviews

Together, the above results provide important insights into defining adaptability in the context of engineering work as perceived by engineering managers. Most behaviors identified in the engineering manager interviews mapped to behaviors in Pulakos et al.'s (2000) framework for adaptive performance in the workplace: Creative Problem Solving, Demonstrating Interpersonal Adaptability, Handling Work Stress, Dealing with Uncertain and Unpredictable Situations, and Learning New Tasks, Technologies, and Procedures. However, there were two emphasis areas found in this work: (a) an emphasis on Knowledge Transfer in relation to Learning New Tasks, Technologies, and Procedures, and (b) a different understanding and inclusion of Cultural Adaptability. These expand the understanding of adaptability for the scientific and technical workforce presented by Kantrowitz (NASEM, 2018) based on Pulakos et al. (2000).

Comparison to Pulakos et al. (2000) framework

Knowledge transfer. The Pulakos et al. (2000) definition of solving problems creatively includes the idea of integrating unrelated knowledge into the solution of complex problems. However, engineering managers discussed the idea of knowledge transfer more generally and usually in the context of learning and education. For this reason, knowledge transfer was added as an expansion of Pulakos et al.'s (2000) Learning New Tasks, Technologies, and Procedures dimension. Managers shared examples of the importance of not only being able to learn new skills to be adaptable, but also being able to apply those skills in the context of engineering work. Engineering managers specifically were referring to the misalignment between engineering education and practice, which has been highlighted in the engineering education literature by many scholars (Brunhaver et al., 2018; Johri & Olds, 2011; Jonassen et al., 2006; Sheppard et al., 2007; Trevelyan, 2007, 2010, 2013). Recent studies (Barner et al., 2021) have continued to find that this gap persists in engineering classrooms, with academic representations of engineering problems being less tangible to the social and material context of engineering practice. This is an area with a need for continued focus within the engineering education field. In order for engineers to more smoothly transition and adapt to the engineering workforce, there should be great opportunity to explore real-world examples and understand the differences between theory and practice in the engineering curriculum.

Cultural adaptability. Engineering managers also discussed the importance of cultural adaptability for engineers, especially as the engineering workforce becomes more diverse and global. The importance of cultural competence for engineers is supported by the literature (Johri & Jesiek, 2014), with some specific existing assessments like the Intercultural Development Inventory, developed at Georgia Tech (Lohmann et al., 2006), and the Global Preparedness Index (Ragusa, 2011). However, whereas Pulakos et al.'s (2000) definition of cultural adaptability discusses the importance of adjusting behaviors and appearances to assimilate and fit in at work, engineering managers described cultural adaptability in terms of understanding different cultures to develop an accepting and inclusive culture for all. For example, when initially work became more global, there was a lack of understanding of the importance of accommodating other people's holidays or time zones when scheduling deadlines or meetings, such practices which have since been established to negatively impact morale and produce resentment (Kobitzsch et al., 2001). There is now recognition that finding mutually convenient and/or alternating meeting times works for all parties involved (Kobitzsch et al., 2001). The revised definition of cultural adaptability presented in this work reflects this more balanced and compassionate approach. However, some engineering managers conceded that this approach was not always taken, depending on the climate and culture of their organization.

Connections to other engineering studies

Dimensions of adaptability. Some of the dimensions of adaptability identified by managers have been consistently discussed in other engineering education literature, although not specifically related to adaptability.

For example, Lucas and Hanson (2016) considered behaviors like creative problem solving to be one of the "Engineering Habits of Mind" (EHoM) by another study. The National Academy of Engineers (2004) "Engineer of 2020" report alludes to adaptability as dynamism, agility, resilience, and flexibility. It describes the importance of lifelong learning, learning quickly, and applying knowledge to new problems and contexts, which overlap with the adaptability dimension, Learning New Skills, Task and Procedures. It also discusses other attributes that overlap with dimensions of adaptability discussed by the managers, such as creativity (related to Creative Problem Solving), and communication with multiple stakeholders (related to Interpersonal Adaptability). Similarly, although ABET does not directly name adaptability as a key learning outcome for engineering students, there is overlap between the skills they list and adaptability dimensions identified by the managers in this study. Specifically, the ability to solve complex engineering problems by applying science, engineering and math principles relates to Creative Problem Solving and Learning New Tasks, Technologies, and Procedures, and the ability to effectively communicate with a range of audiences and work on teams relates to Interpersonal Adaptability.

Given these mappings, there appears to be potential for the NAE attributes of the Engineer of 2020 and the ABET student learning outcomes to be effectively taught and assessed through the lens of adaptability. The findings from engineering managers also suggest that handling work stress, dealing with uncertain and unpredictable situations, and demonstrating cultural adaptability might be important to emphasize as part of ABET accreditation criteria as well.

Personal influences. The personal traits that engineering managers said were related to adaptability are also supported by other adaptability literature and theories. For example, although Career Construction Theory is related to career adaptability (Savickas, 2013) rather than workplace adaptability, it acknowledges that previous experiences and personal characteristics may play a role in whether an individual is adaptive in a particular situation. These factors map to the specific kinds of experience and self-awareness discussed by engineering managers as important to adaptability, respectively. Further, Lucas and Hanson (2006) also tied adaptability to self-awareness, and specifically, having the self-awareness to know where one fits in a team and what one's strengths and weaknesses are, echoing certain managers. Notably, other personal traits such as self-efficacy, cognitive ability, openness, cognitive agility, and emotional stability have been found to be precursors to adaptability, but with conflicting results (Park & Park, 2019).

Contextual influences. Managers talked about three types of contextual influences in their interviews. The first related to the type of job role or career context the engineer was in. Different types of engineering roles (e.g. manufacturing versus research and development), industries (e.g. heavily regulated), and career stages required different adaptive behaviors. The second related to specific contemporary contexts to which today's engineers must adapt. Examples of these were the increased globalization (Lynn & Salzman, 2006) and continued non- inclusiveness of women and people of color (Bastalich et al., 2007; Faulkner, 2009; Remedios & Snyder, 2015; Robinson, & Mcllwee, 1991) within the engineering workforce, both of which are well-documented in the literature. The third was related to contextual supports (or barriers), which can influence whether and how an engineer adapts, as has been backed up prior work. For example, Han and Williams (2008) found that access to continuous learning activities and team learning climate predicted individual adaptive performance among a sample of Korean employees. In another study, Griffin and Hesketh (2003) determined that employees who rated their work environment as challenging and complex and who reported higher levels of support from management were more likely to be described by their managers as better performers of adaptive behavior. Charbonnier-Voirin et al. (2010) found that support from coworkers, supervisors, and the organization predicted individual adaptive performance, just as Chiaburu et al. (2013) found that a combination of transformational leadership and climate for innovation within the organization did.

Together, these studies suggest that contextual support at the team, management, and organization levels impact the behavioral (i.e., task) adaptability of individual employees. They also point to a need to further examine the effect of contextual influences on individual adaptability, perhaps by integrating contextual influences at the team and organization levels into a multi-level approach for understanding workplace adaptability, per Kozlowski & Klein (2012).

Adaptability balance. Within these contexts, engineers often described that there needs to be a balance in adaptability—meaning that it is unreasonable to expect individual engineers to be the only ones to adapt—for person-organization fit, it is also important that leaders and organizations are flexible and have adaptability as well. The managers expressed that there are times it is appropriate to not be too adaptable and instead essentially push for change within the organization or context. It is important that as students are taught to be more adaptable it is conveyed to them that their adaptability does not mean to bend to all whims of the organizations in which they work, but to harness the awareness to know what is best for them and the broader context of their work. Engineering students and future leaders must learn to balance these characteristics to make change and be efficient in their work, including as it relates to making workplace more equitable and inclusive for all.

Composite Narratives

Overview of Composite Narratives

Seven composite narratives were developed, with six related to the different behavioral dimensions of adaptability for engineers and the last illustrating the idea of adaptability context and balance. Notably, each narrative does not necessarily cover every aspect of its corresponding adaptability dimension, and some narratives feature aspects of multiple adaptability dimensions. Situations covered by the narratives include having to navigate: a market change due to new technology or evolving customer needs, a project cancellation or failure, a technical or design challenge, intense and varying workloads, a culture change due to a merger or acquisition, working with a new group, team, or company with different cultural norms, learning a new skill or tool, unclear communications between employees or other stakeholders, and unforeseen circumstances, such as the COVID-19 pandemic or a rare technical failure. A mapping between the compositive narratives, their related adaptability dimensions, and the type of situation covered is presented in Table 8. While the composite narratives do not cover every type of situation described by the managers in their interviews, they act as a starting point for deeper understanding of the situations to which engineers must adapt.

Table 8

Composite Narrative Titles

Title	Dimension and Situation
So, we know this is not necessarily what we hired you for…	*Dealing with Uncertainty:* Job Role Change
Let's figure out what actually is happening…	*Interpersonal Adaptability:* Communicating with an External Supplier
Oh, I didn't know it could fail that way…	*Creative Problem Solving:* A Technical Challenge
The sky is falling…	*Handling Work Stress:* Catastrophic Product Failure
When you see something that someone's doing better…	*Learning New Skills:* Automation of Work
You can't just be standing on the sidelines…	*Cultural Adaptability:* Working Across Different Functions and Companies
The balancing act…	*Adaptability Context & Balance:* Working in a Male-Dominated Field as a Woman

Dealing with Uncertain and Unpredictable Situations

The composite narrative in Figure 2 describes a situation in which a new engineer is hired into a specific role but ends up needing to adapt to working in a different role. Engineering managers described observing this type of scenario occur to engineers at various career stages and for different reasons, such as a project cancellation or failure, or a company re-organization due to a merger or acquisition.

Figure 2

Composite narrative related to dealing with uncertain and unpredictable situations

So, we know this is not necessarily what we hired you for…

As a recent graduate, Sofia is excited to be a design engineer – a role she is passionate about and has experience in. The role is related to her capstone project, so she feels she has relevant experience to contribute. She starts her new position, and two weeks later, she gets some disappointing news—the project she was originally assigned to has been shut down. Her manager says,

> "We're going have to find you a new job. We don't know what it's going be… Sorry, your product is going away. We're really glad you're here. Just hold tight. Here's some training, we have to figure out where we're going."

Sofia's first reactions are loss, fear, and frustration. Sofia has some mentors at the company that she can talk to, and she expresses her concerns: What's going on? What does it mean? What's going to happen? How will it work out? She starts to understand that shutting down the project is the right decision for both the team and the business. A few days later, she gets an update.

> "All right, you're going to be on this new team and be focused on a different product. So, we know this is not necessarily what we hired you for, but it's similar… similar skillset, similar role, but different projects."

She knows she is going to have to learn some new skills to work in this new role. The transition is not happening quickly—it is projected to take over a month! So, she takes the time to start learning. She finds small projects she can take on and tries to learn as much as she can. She really takes this new project as an opportunity to learn, broaden her network, get to know more people, and make connections within the organization. She successfully transitions into her new role.

Sofia is very open to being able to work on different projects and is having success in this new area. However, as she continues to learn and contribute more, she realizes, "This isn't necessarily where I want to be." Sofia still wants to work on design related to the original project that she was hired for, and she starts to talk to her manager about her career desires. Her manager tells her,

> "You have to look at what are the other areas that excite you so that you can leverage your competency, your energy and your passion, and we can look at where we can move you."

Sofia and her manager work together to assign her to tasks that better match her skill sets and career desires in alignment with what the business needs, figuring out a solution that suits everybody.

Context and Key Points: "*So, we know this is not necessarily what we hired you for. . .*".

This composite narrative describes a successful instance of an early-career engineer dealing with uncertain and unpredictable situations at work because they refused to be paralyzed by uncertainty or ambiguity. Instead, they changed gears and imposed as much structure for themselves as possible in the situation by engaging in multiple coping strategies: learning new skills, reaching out to mentors, being open to new projects, seeking out small projects, developing awareness of their own interests, and getting to know more people in their organization.

Engineers whom managers said were able to adapt in this situation seemed to be influenced by two contextual supports. The first was psychosocial support from mentors in the organization who helped contextualize the reasons for project cancellation and reassured the engineer that they would be okay (e.g., Brunhaver et al., 2010). The second was a sense of relational empowerment, i.e., feeling in control of work tasks and assignments due to positive interactions, such as with one's manager, that provide a sense of agency or autonomy over one's work (e.g., Lutz, Canney, and Brunhaver, 2019).

Notably, some managers described situations in which engineers were confronted with a similar situation as presented in this composite narrative and took a different path. Engineers who were later in their careers and had either developed a particular niche or had a Ph.D. in a particular area were more likely to leave the organization, perhaps because their high level of specialization made it either more difficult to adapt or more unlikely that they would want to. Thus, this narrative supports previous findings that having specific kinds of experiences can make engineers more or less likely to adapt.

Interpersonal Adaptability

The composite narrative in Figure 3 was based on two excerpts in which managers described an engineer having to communicate with their product team and an external supplier about a part misspecification, respectively. Managers often discussed the importance of open communication with many different kinds of stakeholders, including suppliers, customers, and those in other functional areas within their organization. In this particular narrative, open communication becomes especially important, since the engineer's initial assumptions about part are proven false.

Figure 3

Composite narrative related to interpersonal adaptability

Let's figure out what actually is happening. . .

Dan, an engineer with about two years of work experience, has been working with an outside vendor on a part of a catheter delivery system for about six months. The system has a distal tip bonded to it, which requires tensile testing upon full assembly. The quality assurance unit within his organization approaches him and informs him that the distal tip is no longer meeting specification. He assesses that the supplier must have made a change in the manufacturing of the part. Dan understands bonding well and hypothesizes that it's possible the supplier had made changes to their process to result in these issues. He schedules a brief call with the supplier, during which they inform Dan that nothing has changed in their process. It is clear to Dan that something is not adding up.

Dan talks with his product team, and they agree with Dan's initial assessment—there must be something wrong with the supplier part. Dan's manager immediately sends him to the supplier's facility to learn more, saying, "Let's figure out what's actually happening." Dan is eager to investigate. Before he departs, a senior engineer coaches him to recognize the importance of listening, and not to jump to conclusions or blame, upon his arrival. Dan spends a week at the facility talking to their engineering team, including observing the tip bonding process—he feels like he is learning a great deal. Dan articulates his concerns about the specification and provides background information about the issue. However, Dan's organization had been working with this supplier for a long time—20 years—and the supplier is adamant that nothing has changed in their process. Dan continues to stay curious and ask questions. He is determined to find the solution.

Eventually, Dan concedes that he is unable to find anything wrong with the supplier's tip bonding process. Despite his technical knowledge on the topic, he is still unsure as to why parts are failing to meet specification. The supplier's engineering team shares some stories about how often customers change designs and specifications—they feel that they always have to be ready for change. Dan finally thinks to recheck his assumptions—is it possible that there had been a design or specification change with his company's product? After returning to his workplace and doing some internal investigating, he finds that the quality assurance unit has tightened the testing window without telling Dan's product team. He then initiates conversation with the supplier to meet the new specification and is glad that he did not start his initial interactions with them by casting blame.

Context and Key Points: ***"Let's figure out what actually is happening. . .".***

This composite narrative describes a successful instance of an engineer adapting interpersonally at work because they were willing to stay curious and open-minded about the other party's perspective until a conclusion was reached. The engineer listened to others' viewpoints and opinions. Exhibiting this type of interpersonal adaptability is extremely important in engineering, where much of engineering is "concurrent" engineering, necessitating the need for good communication.

However, not all such instances that managers described of engineers needing to adapt this way ended as positively. In some instances, the engineer was unwilling to check their assumptions or entertain other possibilities, instead choosing to focus on one solution and accusing the other party of fault. Although engineers are often taught to check their assumptions in their engineering problem set classes, this is evidence that they may not transfer that skill to their interpersonal interactions or problem solving.

Separately, this narrative sheds light on another contextual support that may influence engineers' adaptability– having a more experienced engineer provide coaching and role modeling. Coaching and role modeling has been shown to support personal adaptability in certain types of mentoring relationships (Weinberg, 2019). In this case, the mentor coached the engineer on how to communicate with the supplier in an open way without casting blame and to listen as much as possible. This coaching ended up being crucial to navigating the situation.

Cultural Adaptability

The composite narrative in Figure 4 combines two incidents shared by managers that revolve around an engineer's need to work with their organization's marketing team and an external supplier – both of which have different cultures than they are used to – to get a part changed to meet technical specifications. The narrative demonstrates the importance of the engineer adjusting their interactions to each group's way of doing business to reach a successful outcome. Managers discussed in their interviews the importance of understanding that different project teams, functional units, and organizations often have different cultural norms than an engineer's own.

Figure 4

Composite narrative related to cultural adaptability

You can't just be standing on the sidelines…

Sam is an engineer working with their organization's marketing team on the development of a new product. Their meetings with the team have been going well, until Sam and the team start discussing a use case that the product's technical specifications do not support. Sam realizes that the part cannot be easily changed to meet specification, as it comes directly from a supplier. They express their doubtfulness to the marketing team, who don't seem to appreciate the magnitude of the change they are asking for. Some back and forth between Sam and the marketing team ensues. Ultimately, it becomes clear just how important it is to the marketing team that the part be changed – they believe it's critical to the successful marketability of the new product. Sam decides to investigate whether a change is possible with the supplier, asking, "How can we actually change this?".

Sam uses their background as a quality engineer to produce a report for the supplier outlining the changes the marketing team would like to see made to the part. They do not intend for the report to seem critical of the supplier's operation – after all, they are trying to negotiate a solution with the supplier – but the supplier seems to interpret things that way. Although Sam and the marketing team are clear on the direction the part needs to go in, the supplier informs Sam that the changes suggested are not cost effective nor technically feasible. Having a pretty good feeling that neither claim is true, Sam feels frustrated.

Sam asks around at his company and learns that this supplier's cultural norms are different than what Sam is used to. Whereas in Sam's company, there is a separate team that takes concerns from the quality engineering unit and implements solutions, the supplier does not have such in-house capacity. Sam's manager suggests that, to change the part's technical specification, "You have to get out there in the field and participate … To solve this issue and get buy-in, you will need to get into the technical details [with the supplier], you can't be just standing on the sidelines".

Sam wants to solve the problem and, therefore, changes their approach. They offer to observe and learn more about the supplier's manufacturing processes in person and work together on developing a possible solution. All in all, the project takes a year to complete. However, the part is changed to meet specification, and the solution that Sam develops with the supplier is much more cost effective than the initial proposal. Having to oversee such a big change is daunting for Sam, requiring them to work outside their wheelhouse with both their internal marketing team and an external supplier, but they learn valuable new skills in the end.

Context and Key Points: ***You can't just be standing on the sidelines….***

This composite narrative illustrated two instances in which the engineer successfully adapted to another party's cultural norms and objectives. First, the engineer had to negotiate the change in the specifications to a part with the company's marketing team. The marketing team articulated that the change was critical to the product's marketability, while the engineer knew the part was manufactured externally and would not be easy to change. After eventually acquiescing to the marketing team after a long and drawn-out process, the engineer needed to work with the external supplier to implement the change. The external supplier did not appreciate being told what was wrong with the part without suggestions for how to fix it. The engineer had to adopt a different, more collaborative approach with the supplier to make the change. In both instances, the engineer had to understand the other party's opposing viewpoint and adjust their perspective or communication style to reach an agreement with them, respectively.

Having a network of colleagues with whom to consult played a critical role in the engineer's ability to troubleshoot their breakdown in communication with the external supplier. Direct intervention from their manager also helped the engineer realize they should work with the supplier to identify a solution to the problem rather than continue to act as an observer on the sidelines.

The composite narrative also included multiple dimensions of adaptability. The engineer had to handle the stress of the situation, describing it as frustrating for them at times. They also had to learn to exhibit interpersonal flexibility to effectively work with both the marketing team and the supplier.

Creative Problem Solving

This composite narrative combines two excerpts from the interviews with managers where an engineer had to solve a technical challenge. In both instances, the managers described how the engineer successfully navigated the situation by using brainstorming and listening to ideas. The managers emphasized the importance of engineers being open to finding the best solution to the problem rather than relying on the solutions they were most familiar with, or that proved ineffective.

Figure 5

Composite narrative related to creative problem solving

Oh, I didn't know it could fail that way. . . The engineering team has finally made it to Performance Qualifications (PQ), one of the final steps to having their manufacturing process validated. However, a small defect keeps appearing, something they have not seen before. At first, the team makes some observations and then implements a minor fix to the operating procedures, thinking it is being caused by human error. However, now the issue is still occurring but with decreased frequency, and the deadline to get the process up and running so that parts can be produced is quickly approaching. Upon seeing the error happen herself for the first time, Shannon – an engineer on the team – says, "Oh, I didn't know it could fail that way!" She takes a step back and thinks, "Okay… That fix didn't work, but it had some semblance of good, so what can we build on that?" Since the original solution did not work completely, Shannon decides it is time to think outside the box and consider entirely new solutions. Recognizing at this point that she does not have all the answers, she assembles a group of other engineers, manufacturing operators, and experts from other product areas to learn and brainstorm as much as she can about the problem from multiple perspectives. Based on the group's discussion, she recommends her engineering team divide into small subgroups and assigns each one a unique role in investigating the problem and potential solutions further. She is careful to listen to each sub team's ideas and does her own observations when possible.

Under Shannon's leadership, the engineering team amasses a large amount of data from which they are finally able to identify the problem—and it is nothing like they originally guessed. Shannon returns to her cross-functional group of advisors and informed by their unique insights, helps guide her team to the best possible solution for the organization after some trial and error. The solution is easily accepted across units, including manufacturing where the operators are quick to adopt it because they were able to provide input and ensure their needs were considered. Shannon receives praise from her team for recognizing the importance of seeking multiple perspectives during creative problem solving.

Context and Key Points: *"Oh, I didn't know it could fail that way. . .".*

This composite narrative describes a successful instance of an engineer creatively problem solving at work. Three contributing factors contributed to the engineer's success. First, the engineer did not work alone and, instead, had the self-awareness to realize that convening a team with varied expertise could be helpful in this situation. Second, the engineer remained open to all types of solutions and used data to reach an informed solution. Third, they learned from mistakes made when the initial solution did not work as planned.

Regarding contextual supports, an organization with more open communication and fewer silos can act as catalysts to adaptability. In this case, the engineer having access to coworkers with varied experiences was key to solving the problem.

Lastly, this narrative involved interpersonal adaptability, in addition to creative problem solving. The engineer coordinated brainstorming sessions with other members of their organization, allowing different perspectives to be shared, and were open to solutions not apparent from an initial assessment of the problem.

Handling Work Stress

This composite combines two excerpts from engineering managers. In one excerpt, the manager described an engineer dealing with the work stress of tight timelines and a 40+ hour work week. In another excerpt, the manager described a stressful situation for an engineering team in which they put years into a product, only for testing to result in a catastrophic device failure that could cause harm to a customer. Details of the product failure have been changed and redacted to maintain anonymity, with the focus on how different team members reacted to the stressful situation.

Figure 6

Composite narrative related to handling work stress

The sky is falling. . .

The engineering team has been working on their product for four years. Each and every team member is passionate about and invested in the product. After years of design work, it is finally time to migrate from design simulations to physical tests of the device in action. The team knows it could be a great contribution to the field if this test is successful. On the first day of testing, the entire team is there to record observations.

Knowing how much blood, sweat, and tears the team had put into this work, Tracy – a new engineer on the team – feels a combination of excitement and nervousness as testing begins. As signs of failure become apparent, Tracy begins to feel massive disappointment and scans the room. Some engineers have their heads down, and another colleague is quickly pacing the room. Other senior engineers are frantically writing in their notebooks and taking observations.

"Oh no, what's going to happen?," Tracy thinks. Tracy feels frozen in place. They feel like it is all happening too fast, and they are surprised that some of their colleagues can maintain their composure and continue to collect data given what is unfolding before them. One colleague begins frantically talking about whether it is possible to make certain changes to the design in a reasonable timeframe. However, even Tracy knows, despite their limited time at the company, that these alternatives have already been tried and that the design is just not going to work because the team had made erroneous assumptions. Instead of the great step forward expected, it is clear the team has taken several steps back that requires returning to the drawing board. Tracy's racing thoughts begin to manifest physically. They start to feel physically ill and think, "Oh my, the sky is falling."

After a few moments, one of the project managers begins to speak calmly, explaining that the team knew there were clear unknowns coming into the product development and that failure and setback are expected parts of the process. Tracy takes some time to regain their composure, realizing that the manager is right while also accepting that their initial reaction was reasonable. They eventually join their colleagues in writing down their thoughts and observations. Although this situation is stressful, they realize that they need to keep cool and use this opportunity to gain insights into what went wrong with the design.

Context and Key Points: *“The sky is falling. . .”*.

This compositive narrative describes a successful instance of an engineer handling their work stress. They did not overreact to the unexpectedness and disappointment of the device failure and instead demonstrated resilience and professionalism. Engineering managers highlighted the importance of maintaining composure in these circumstances, even when compounded with pressure from others in the organization, financial concerns, or uncertainty about one’s future within the company. Managers also recognized that creating a calm environment in these types of situations was part of the manager’s role. They noted that, while an emotional reaction such as grief or shock is normal at first, more experienced engineers are quick to direct their efforts toward troubleshooting and data collection to diagnose the problem.

Learning New Tasks, Technologies, and Procedures

The composite narrative in Figure 7 combines three excerpts from the managers related to learning new tasks, technologies, and procedures on the job. A manager reflected on their own experiences and gave examples related to adjusting to new tools and automating a process. Multiple managers mentioned the use of software tools to improve workflow, saying this was an important component of adaptability. Engineers were praised for seeking out new knowledge and skills and adapting solutions in the context of their work.

Figure 7

Composite narrative related to learning new tasks, technologies, and procedures

When you see something that someone’s doing better. . .
Darian notices that, even in his relatively short 20-year engineering career, he has seen countless changes. From digital work tools and simulation layouts with more capabilities, to different vendors and the products themselves, he has constantly needed to learn new things.

When he had first wanted to study engineering, he had pictured it all differently—that his work be very hands-on, drawing sketches with pen and paper or maybe a drafting tool. However, almost all his work is now done with a computer. He has had to learn how to communicate via video calls, text chats, and email, especially now that the COVID-19 pandemic has moved all of his work meetings virtual. Darian notices that if he has already experienced this much change in his career, the next 20 years will bring even more change.

When Darian notices his colleague completing assignments much faster than normal, he grows curious about how. They are not on the same project but perform similar functions that can be quite tedious at times. Darian talks to his colleague and learns that she has used a script to automate part of the process. She says to him, "Why would you want to do something that is fairly tedious work and takes a long time when you can find a more efficient way of doing it?" Darian is amazed that he could apply this technology to make his work easier and agrees. He asks his colleagues for pointers about how to create his own script and, based on her suggestions, consults various resources. It takes him some extra time to learn the process, nearly twice as much time as if he had done the project the way he normally does. However, the next project goes twice as fast, and the quality is even better because he has time to check his work.

Darian finds that learning this automation tool has many benefits. His job becomes easier and more fun, he can focus on other aspects of his work (such as design) that he is more interested in, and he shares the tool with the rest of his project team, which is a contribution praised by his manager. Darian wants to challenge himself to automate additional parts of his workflow that also take a long time next.

Context and Key Points: "*When you see something that someone's doing better. . .*".

This compositive narrative describes a successful instance of an engineer learning a new tool because they were enthusiastic about learning the new tool, identified what they needed to learn, and executed the necessary learning.

In this situation, a coworker helped the engineer adapt to the situation by sharing a new tool with them. This narrative also underscores the importance of self-awareness, in that the engineer needed to be self-aware that the task could be done more quickly and that they could ask for help from someone who knew how to do it better.

The engineer in this narrative was also described as weighing how much time to spend developing a script versus doing the tedious task by hand. This makes sense in the context of a repeated task but may make less sense for a task done rarely. This gauging of the cost of investing in automating this task is an example of adaptability balance.

Adaptability Context and Balance

The composite narrative in Figure 8 highlights some of the challenges the current engineering culture presents and the challenges engineers can face in pushing against the norms. The composite is developed from three manager excerpts, wherein one describes the lack of gender and racial diversity present when moving up within their organization, one describes her personal experience in this white male-dominated environment as a woman of color, and one describes the challenges related to being an engineer pushing for organizational change.

Figure 8

Composite narrative related to balance and context

The balancing act. . .

Hannah has been working as an engineer for eight years. She is ambitious, eager to advance in her job, and wants to one day be part of the prestigious group of technical fellows at her company, for example. However, she is starting to notice some gendered aspects of her workplace. She already observed that her engineering department is not particularly gender-diverse but was surprised at how gender diversity dwindles even more among higher levels within the company. Among the 60 technical fellows, only one is a female and received this recognition only just last year. She wonders how long it will take for the group of technical fellows to represent the population of engineers working at her company.

Hannah has recently been promoted to a new product team and now has more responsibilities, including managing a team and interfacing with customers. The customers are physicians, and she has been looking forward to working with them, except that she finds herself adjusting her behavior around her new, mostly male, engineering colleagues. Although her male colleagues address the physicians by their first names, she always addresses them by “Doctor” and their last names. Hannah feels like she must be extra respectful to be taken seriously. Often, she is interrupted by her male colleagues when speaking and feels like she cannot voice her opinion. However, Hannah never pushes back because she is worried about being labeled as challenging. During her first company trip with the new team, she hears her male colleagues making inappropriate jokes that are sexist and offensive. With her friends and family, she would say, “That was not appropriate. You should not say that”, but in this context, she thinks to herself, “I don’t want to be the one to call them out.” In general, she feels like she needs to be inauthentic to herself to be accepted and fit in.

Hannah wants to take initiative and change her work environment. In particular, she wants to help other women of color like herself to advance within the organization and excel. She balances being respectful to her male colleagues so that she can move forward in her career, facilitated by their approval, with looking for ways to make change within her organization. One day, she voices her concerns and desires to her supervisor, expressing doubts about whether she should stay at the company. Her supervisor takes her concerns seriously and approves the resources she needs to grow a more gender and racially diverse product team within her department.

Context and Key Points: ***"The balancing act. . ."*.**

It is important to understand the complexity of the engineer's situation in this narrative. The engineer, a woman of color, is trying to adapt to an engineering environment that is not inclusive. The composite highlights the additional barriers that women of color may face when adapting to the engineering workplace, particularly to an environment that may be unsupportive and unwelcoming.

The engineering workplace's slowness in becoming more inclusive is well documented (Pew Research Center, 2021). The reality in the existing engineering culture is that there needs to be systemic change to develop more catalysts and inhibit barriers to adaptability so that the field can be more inclusive. Managers discussed in their interviews that certain contextual factors can be barriers or catalysts to adaptability, such as the work environment, managers, mentors, and coworkers. In this case, the engineer's coworkers were a barrier to her adaptability and her supervisor a catalyst.

Until engineering workplaces become more inclusive, women (and others in engineering who have been systemically excluded) in some organizations may be resigned to facing additional barriers in adapting to the environment until they can secure power or find supportive leaders willing to make change, as in this story. This resignation may be especially unavoidable in cases where engineers are concerned about discriminatory job loss (Bell et al., 2013). At the same time, managers pointed out that there were situations in which it may not be appropriate to adapt, specifically in hostile or toxic environments.

Some managers suggested the importance of finding a supportive team, either through finding an alternate team at the company, or alternate employment. .

Discussion of Composite Narratives

The composite narratives presented in this chapter provide a range of the different critical incidents and events engineers may face in the workforce, as shared by engineering managers. Relative to the critical incidents, the composite narratives can better illustrate how personal traits influence whether and how much an individual adapts. In two narratives (*When you see something someone's doing better…* and *I didn't know it could fail that way…*), engineers required self-awareness to realize that they did not have enough knowledge or information and needed to ask for help. These narratives also demonstrated the importance of time related to adaptability. In one narrative, an engineer takes time to experience grief when a product fails, and in another an engineer needs time to learn a new skill that will expedite their work in the long term.

Further, the narratives illustrate the role that experience can play in an individual's capacity or willingness to be adaptable, depending on context. In one composite narrative (*The sky is falling…*), more experienced engineers were more readily able to move on and resume work after a catastrophic device failure as compared to less experienced engineers. However, in another composite narrative (*So, we know this is not necessarily what we hired you for. . .*), those with more schooling or specialization in a certain niche were less inclined to be adaptable than an early-career engineer with less schooling and more general skills.

The composite narratives also demonstrate how important contextual support (e.g., from managers and coworkers) is to engineers' adaptability. The help that managers alluded providing to engineers included reassurance, big picture context, empowerment, advice, coaching, role modeling, and more. These forms of contextual support are also linked to positive employee outcomes in general (e.g., Amabile & Gryskiewicz, 1989; Gould-Williams & Davies, 2007; Kim, 2014), raising the question whether satisfied and well-supported engineers tend to be more adaptable overall.

Additionally, the composite narratives help show how multiple dimensions of adaptability overlap and work together. For example, the narrative for dealing with uncertain and unpredictable situations (*So, we know this is not necessarily what we hired you for…*) also alluded to learning new tasks, technologies, and procedures. The narrative for creative problem solving (*When you see something that someone's doing better*. . .) also suggests that the ability to handle work stress and interpersonal and cultural adaptability greatly facilitate engineers to solve complex technical problems that they could not otherwise solve by themselves. Further, any time an engineer leverages a contextual support likely involves some degree of interpersonal adaptability, depending on the situation.

The composite narratives can be combined with probing questions to stimulate thinking, learning, and discussion related to adaptability in both academic and industrial educational settings. These questions could include: (1) how would you react to this situation, (2) what steps would you take in this situation, and (3) what would you do or say if you saw this situation happen to someone else, as well as other questions more specific to the particular narrative. (E.g., "how would you approach learning a new tool?", and "how would you decide whether it is worth learning a new tool?," for the scenario related to learning new tasks, technologies, and procedures.) Probing questions for each composite narrative are shared in Table 9. The narrative could be shared first as a scenario, followed by the probing questions and then, later, the additional context and key points. The goal of sharing these narratives would be for students to consider the complexities of these composites and how they believe an engineer should adapt in each situation. Further, part of the goal of this exercise would be for students to realize that there are multiple approaches to how they can adapt depending on the context. These composite narratives developed from the research can be used as the basis for adaptability-related interventions in the classroom. A pilot using scenario-based learning is presented in the next section. Other implications of the composite narratives for education will be discussed in the conclusions chapter.

Table 9

Probing Questions for Composite Narrative

Composite Narrative	Probing Questions
So, we know this is not necessarily what we hired you for… (Dealing with Uncertain and Unpredictable Situations)	If presenting this scenario, it is suggested that only the first paragraph be shared, followed by these probing questions: ● How would you react to this situation? ● What steps would you take in this situation? ● What if you were stuck in between roles? ● What if you did not enjoy the new role? ● What if your manager did not listen to you? ● What would you do or say if you saw this situation happen to someone else?
Let's figure out what's actually happening… (Interpersonal Adaptability)	If presenting this scenario, it is suggested that only the first paragraph be shared, followed by these probing questions: ● How would you react to this situation? ● What steps would you take in this situation? ● How would you present your findings to your team? ● How would you communicate with the supplier? ● What if the supplier insisted nothing has changed? ● What if you could not find any evidence of change? ● What would you do or say if you saw this situation happen to someone else?
You can't just be standing on the sidelines… (Cultural Adaptability)	If presenting this scenario, it is suggested that only the first paragraph be shared, followed by these probing questions: • How would you react to this situation? • What steps would you take in this situation? • How would you communicate with the marketing team? • What if they insist this use case is necessary? • How would you communicate with the supplier?

	• What would you do or say if you saw this situation happen to someone else?
Oh, I didn't know it could fail that way… (Creative Problem Solving)	If presenting this scenario, it is suggested that only the first paragraph be shared, followed by these probing questions: ● How would you react to this situation? ● What steps would you take in this situation? ● What if the solution only works sometimes? ● What would you do or say if you saw this situation happen to someone else?
The sky is falling. . . (Handling Work Stress)	If presenting this scenario, it is suggested that only the first two paragraphs be shared, followed by these probing questions: ● How would you react to this situation? ● What steps would you take in this situation? ● How would you manage your feelings of stress? ● How would you interact with others? ● What would you do or say if you saw this situation happen to someone else?
When you see something that someone's doing better. . . (Learning New Tasks, Technologies, and Procedures)	If presenting this scenario, it is suggested that only the first two paragraphs be shared, followed by these probing questions: • How would you react to this situation? • What steps would you take in this situation? • How would you approach learning new skills? What resources would you use? • When would you decide to learn new skills versus using a previous method you know well? • What would you do or say if you saw this situation happen to someone else?
The balancing act. . . (Adaptability Balance)	If presenting this scenario, it is suggested that only the first two and a half paragraphs be shared, followed by these probing questions: ● How would you react to this situation? ● What steps would you take in this situation? ● What if this job is very important to you (financially or otherwise)? ● What if the job is affecting your mental health? ● What would you do or say if you saw this situation happen to someone else?

Classroom Intervention

Overview of Classroom Intervention

A classroom intervention was piloted in three sections of a first-year introduction to engineering design course at a large, public southern university in the United States at the end of the Fall 2021 semester. The intervention was meant to increase student awareness of adaptability as an important skill to possess in the engineering workplace.

A summary of day-of logistics and memos written to capture the researcher's thoughts and observations after each time the intervention was piloted is presented below. These are followed by an analysis of student definitions of adaptability before and after the intervention, student responses related to what they would do in each scenario, and student post-activity reflections on what they learned in the class session.

Student definitions of adaptability mirrored the definitions provided by managers, with definitions related to creative problem solving being the most common initially. Many students' definitions of adaptability were more multi-faceted and reflective of the adaptability dimensions emphasized in each of the scenarios after the activity. Students perceived the activity positively overall, and students also included elements like adaptability context and balance in their definitions after the intervention. Further, in the reflection about the intervention, students reported a better understanding of engineering work, an expanded definition of adaptability, greater delineation of adaptability, increased self-awareness, an appreciation for adaptability balance, and enhanced feelings of job preparation.

Summarized Day-of Logistics and Memos

The intervention occurred during a 50-minute class session of the first-year introduction to engineering design course. The researcher began the class by asking students to write how they perceived engineering adaptability. No definition of adaptability was provided to students before asking this question, therefore, providing a baseline of their perceptions of adaptability before the intervention. Next, two scenarios were shared with the students. The presentation of both scenarios followed the same format. The researcher read the scenario out loud and shared the scenario via a PowerPoint presentation. Students then were asked to write what they would do if they encountered the scenario presented and were encouraged to discuss their ideas with their peers. The researcher next presented the students with additional context to the scenario, and students were once again asked to record what they would do in the scenarios and encouraged to discuss their responses with peers. A debrief of what managers reported occurring in the critical incidents on which the scenario was based followed, after which students were asked to share whether and how their definition of adaptability had changed. Pear Deck (a Google slides plug-in to create slides that allow student engagement) was used as a tool to collect all student responses. Finally, the researcher provided a brief presentation on adaptability based on the manager interviews (Appendix D). Students then were instructed to complete a reflection worksheet that included a question on what they learned about adaptability during the session.

Students appeared engaged in each section and, when given the opportunity to discuss their ideas with one another, shared a variety of perspectives. Discussion among the students could be easily heard from the front of the classroom when students were asked to share their responses with each other. Students especially discussed the interpersonal interactions they envisioned they would have and what they would say in response to each hypothetical scenario. In many instances, students surprised one another with their proposed approaches for addressing the scenarios, demonstrating the scenarios' utility in generating impactful discussion.

Overall, each scenario activity took approximately twenty minutes to complete. The content was covered more quickly in the first section than in the subsequent sessions, where the content was presented more slowly, and students' responses were discussed in more detail. The time given for each set of written responses from students also varied slightly from class to class, as the researcher was able to watch the students typing and submitting their responses in real time within Pear Deck.

Comparing Student and Manager Perceptions of Adaptability

Students who participated in the classroom intervention and managers who participated in the qualitative critical incident interviews showed alignment in their perceptions of engineering adaptability. Students identified the same dimensions of adaptability as important to engineering, and sometimes even the same personal and contextual traits that influence adaptability, that the managers did. The same codebook developed for the manager interviews was, therefore, used to code students' definitions of adaptability. Examples of students' responses related to each dimension follow.

Cultural Adaptability. A few students (n = 8 before the intervention, and n = 3 after) described engineering adaptability as the ability to work with people who are different from oneself, whether based on culture, background, perspective, or experiences. The following quotes demonstrate this line of thinking:

> "[Adaptability is b]eing able to work with those of different cultures or experiences. This means being flexible with others." (Drew, pre-response).
>
> "[Adaptability is b]eing able to work with people from a variety of different backgrounds and perspectives" (Andy, pre-response).

Creative Problem Solving. Creative problem solving was one of the most highly cited dimensions of engineering adaptability in students' responses, both before (n = 46) and after (n = 29) the scenario-based classroom activity. Student definitions that included creative problem solving tended to revolve around creativity and using different methods and materials to solve a problem, as demonstrated by the following quotes from students:

> "[Adaptability in the engineering field is] Finding creative solutions to problems." (Erin, pre-response)
>
> "Adaptability can be using different methods and materials to solve a problem." (Sam, pre-response)

Dealing with Uncertain and Unpredictable Situations. Nearly a quarter of engineering students also mentioned dealing with uncertain and unpredictable situations in their definitions of engineering adaptability before (n = 35) and after (n = 46) the activity. For example, one student described adaptability as "[b]eing responsive to unintended and unexpected situations" (Alex, pre-response). Another student shared a similar sentiment, equating adaptability with "[b]eing able to respond to different obstacles quickly and effectively, or working well in unexpected environments" (Casey, post-response).

Handling Work Stress. Of all the adaptability dimensions, the fewest number of students included the ability to handle work stress in both their initial (n = 3) and final (n = 2) definitions of engineering adaptability. One of these students defined "[a]daptability in the engineering field [as] the ability … to work in different environments under different stressors and still get the work completed" (Charlie, post response). Other students highlighted the importance of keeping calm and collected under stress, stating, "In order to be adaptable in the engineering field, one must keep their composure within challenging situations" (Eden, pre-response), and "Being adaptable means being able to work in a variety of situations without shutting down" (Chris, pre-response).

Interpersonal Adaptability. Interpersonal competence was also used to describe engineering adaptability before (n = 15) and after (n = 23) the intervention. For example, one student shared as part of their definition of adaptability: "Being able to thoroughly communicate between different individuals. Not only verbally, but [in] written communication as well" (Ali, pre-response). This student recognizes that the ability to communicate will be applicable to a wide range of contexts and individuals, which engineering managers also frequently noted. Other students also related adaptability to the ability to work well in teams: "Being able to change the way you act or perform to better react with your team/group" (Rome, pre-response).

Learning New Tasks, Technologies, and Procedures. Approximately a quarter of engineering students considered learning new tasks, technologies, and procedures in their responses defining engineering adaptability before (n = 36) and after (n = 35) the activity. Students described being able to learn new skills outside of what they already know, with one student stating that to be adaptable is "[t]o be able to work on different things that [aren't] really necessarily what you learned already but being able to pick [them] up [anyway]" (Ari, post- response).

Further, in the critical incident interviews with engineering managers, participants specifically highlighted the importance of being able to apply and transfer knowledge and skills from the classroom to the workplace contexts. Engineering students (n = 22 before the activity, and n = 16 after) also included this idea of knowledge transfer in their definitions of engineering adaptability. Jan defined adaptability as "[a]pplying what you learned in college to the job, [your] career, and any task that you come across . . . after graduating college" (Jan, pre-response). Similarly, Remy defined adaptability as being able to transfer knowledge across different areas, stating, “Adaptability in the engineering field is having the ability to apply your knowledge to multiple areas, and not just one specific niche” (Remy, post-response).

Adaptability Balance. While no student included elements of adaptability balance in their definitions before working through the scenarios, eight students did so afterward. Examples of how this code manifested in students’ responses were “[b]eing able to know what is best for you as a worker and how you can change (or not change) to better fit your and your company's needs” (Tatum, post-activity response), and being able “to respond to any situation with reasonability while still pushing [to get] growth and experience” (Jessie, post-activity response). In these quotes, students considered the balance in responsibility between the person and the organization in making sure the person adapts effectively to the organization.

Adaptability Context. Only after the classroom intervention did engineering students (n = 10) highlight the importance of context in their definitions of engineering adaptability – this code did not come up in students’ initial definitions. Along these lines, one student defined “[a]daptability in the engineering field [as] the ability to change your plans for a project or job *depending on the circumstance you are presented with* “(Jamie, post-activity response, emphasis in italics added). Another student defined adaptability as “… being able to shift your skill set to *a certain job* that you may have to do” (Angel, post-activity response, emphasis in italics added). Notably, whereas engineering managers’ descriptions of adaptability context tended to be more specific, focusing on particular contexts in which engineers might need to adapt differently, students were more vague about the nature of these circumstances, perhaps because they had less work experience.

Specific Kinds of Experiences. Few students (n = 3 before the activity, and n = 2 after) also discussed the utility of having specific kinds of experiences to being adaptable in their pre- and post-activity responses. This sentiment is exemplified by the following quotes, which defines adaptability as "… being able to apply skillsets you have in a new way" (Tru, post response) and as "using your existing knowledge to solve a variety of skills" (Nova, post response). Many excerpts coded under specific kinds of experiences were also coded under other dimensions since students emphasized both having existing knowledge (specific kinds of experience) and applying it (e.g., creative problem solving and/or knowledge transfer).

Self-awareness. A handful (n = 2 before the activity, and n = 5 after) of student participants included in their definition of engineering adaptability the importance of having knowledge of one's own competency in different areas. This definition aligns with the importance of having self-awareness in being adaptable, which managers also mentioned in their interviews. As one student said, being adaptable is "[b]eing able to work in different situations and … evaluate your competency in that area" (Jude, post-activity response). Notably, the number of mentions related to self-awareness in students' post-activity responses grew after exposure to the scenarios.

Comparing Student Pre- and Post-Activity Definitions

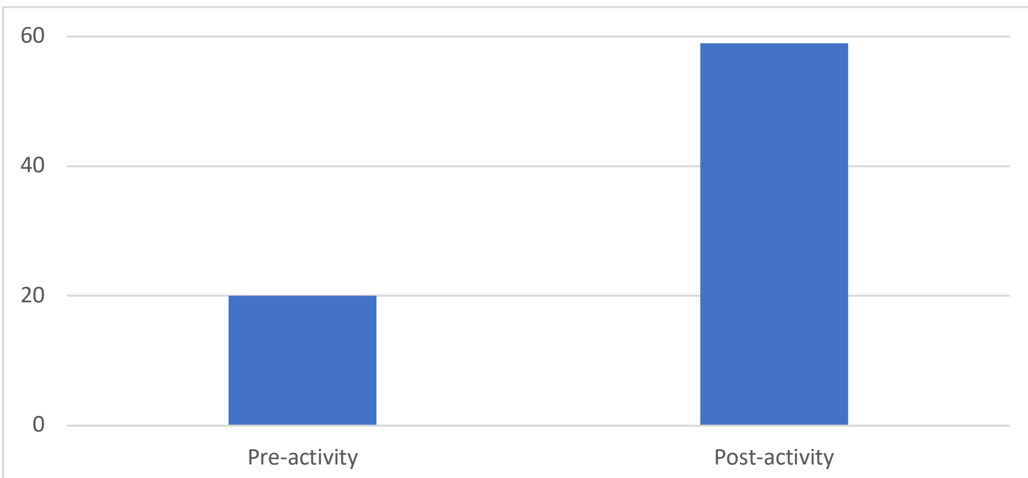
Comparisons of students' definitions of engineering adaptability before and after participating in the pilot intervention revealed four key findings.

1. The number of student definitions that were multidimensional, i.e., referenced multiple dimensions of adaptability from the interviews with engineering managers, increased substantially after the scenario-based activity by a factor of nearly three (Figure 9). As an example of this change, Indigo defined adaptability in the engineering workplace before the activity as "the ability to adjust to the

problems and conditions with which you face" and after the activity as "a culmination of many pieces [including] being able to [find] a job, [adapt to different] job scenarios, [interact] with peers, and … react to [unexpected situations]".

Figure 9

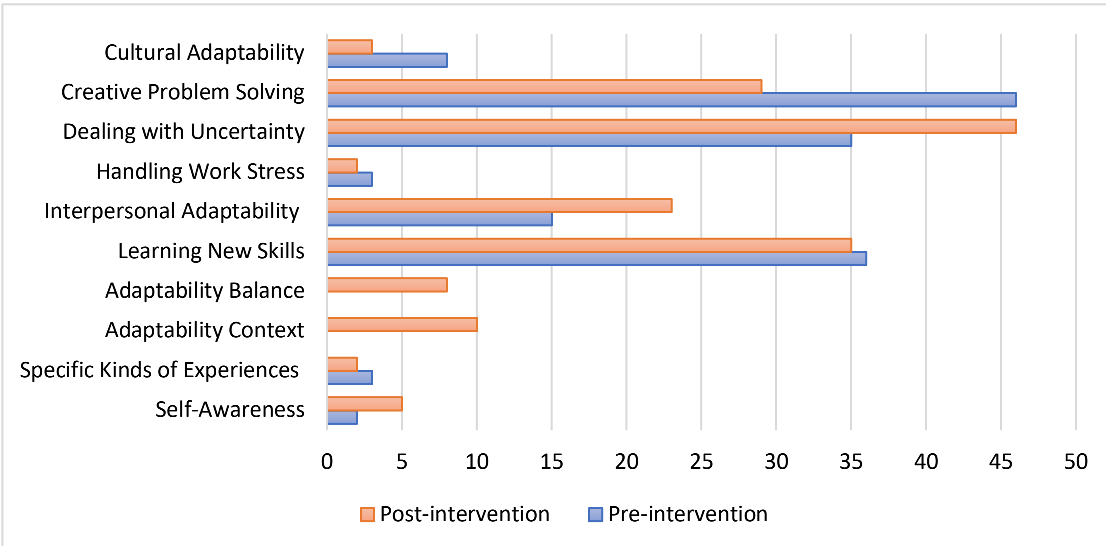
Number of Multi-dimensional Definitions of Engineering Adaptability Before and After the Scenario-based Activity



2. Mentions of managing uncertain and unpredictable situations and interpersonal adaptability (the two behavioral dimensions on which the scenarios were primarily based) increased between students' responses before and after the scenario-based activity. Figure 10 illustrates the number of times students mentioned each code that emerged from the interviews with engineering managers in their pre- and post-activity responses.

Figure 10

Code Counts for Student Definitions of Adaptability Before and After the Scenario-Based Activity (n = 149)



Note. This chart shows the code counts for each student definition. Some students' definitions were assigned multiple codes.

Regarding new mentions of interpersonal adaptability in students' post-activity responses, one student reflected, "I think that my answer stayed relatively the same with one addition. I have to be able to learn new skills quickly, but I also have to be adaptable to the people I am talking to as well" (Harley, post-activity response. Another student shared in their reflection how their definition changed to incorporated dealing with uncertain and unpredictable situations, stating "Originally, I looked at adaptability in engineering as being flexible around problem solving. I learned in class that adaptability is more of handling unexpected difficult situations in an appropriate manner as well." (Teri)

3. Mentions of all other adaptability dimensions, beyond dealing with uncertain and unpredictable situations and interpersonal adaptability, decreased between students' responses before and after the scenario-based activity (Figure 10). For

example, while many student definitions of adaptability revolved around creative problem solving before the activity, this focus decreased substantially in student definitions after the activity. Because many students completely rewrote their definition of engineering adaptability after the class activity, it makes sense that students' revised definitions would focus more on the dimensions which the scenarios covered and less on the dimensions which the scenarios did not cover.

4. As demonstrated in Figure 10, students mentioned the importance of self-awareness and having had specific kinds of experiences on being adaptable – two codes identified by the engineering managers as personal influences on adaptability– in both their pre- and post-activity responses. However, student mentions of adaptability context and adaptability balance – contextual influences on adaptability, per the manager interviews – were found in their post-activity responses only. The scenarios are hypothesized to have prompted students to add this nuance to their definitions.

Student Responses to Scenario 1

The first scenario presented to students was based on the composite narrative, "Let's figure out what's actually happening…". In this scenario, an engineer is confronted with the information that a part no longer meets their company's specification and initially assumes that the part supplier changed their design; by approaching the supplier with an open mind and checking their assumptions, the engineer eventually learns that it is their company's specification (not the supplier part) that has changed. The primary adaptability dimension emphasized in this scenario is interpersonal adaptability, as it could be easy to unnecessarily upset the supplier by casting blame. However, the scenario also emphasizes the importance of understanding and checking assumptions as a part of problem solving, which engineering managers also mentioned in their interviews.

Students were introduced to the scenario and asked how they would respond in the situation. Details of the scenario were intentionally kept vague to encourage students to explore a wide solution space. The students proposed multiple approaches to address the scenario. The most proposed approaches were (1) communicating with the supplier to understand the situation, (44%) (2) confronting the supplier about the situation (34%), and (3) switching to a new supplier (39%). Fewer students talked about stopping to check their assumptions (11%) or updating the part's specifications or making the part in-house so that it is once again compliant (7%). Examples of each approach proposed by the students are provided below.

Communicating with the Supplier. The forty-four percent of students who proposed this approach discussed communicating with the supplier to understand why the part was not meeting specifications. As one student explained:

> "Find a contact and set up a meeting time with the supplier to discuss the specifications. This is important to reach out to the supplier and talk to them to understand where the problem is coming from and find a way to fix it." (Jordan)

Students advocating for this approach also appeared to have greater consideration for the importance of relationship building and flexible communication styles in this type of scenario. They discussed several ways in which they would maintain good communication, including remaining calm, maintaining a respectful tone, and telling the supplier that they had previously done an excellent job supplying the part in question:

> "I would contact them and ask in the calmest way ever [to see] if it was a mix up and to see if we could exchange what we received for what we needed. [We do not] need to make it complicated." (Arya)

> “[I would] bring up how their work had been good in the past and try to find out where the problem is.” (Brett)

Within these responses, students also seemed acutely aware that it was important not to initially accuse the supplier of wrongdoing and instead remain open-minded and ask open-ended questions to determine the source of the problem.

Confronting the Supplier. Thirty-four percent of students indicated that they would immediately confront the supplier and, in some cases, impose specific timelines by which the issues must be fixed and specific consequences that would occur if the issues were not fixed. One student talked specifically about contracts:

> “I would first check to see if there is a contract between the two companies that cites that company A needs to meet specific requirements for company B. I would [then] write an email to whoever is the correspondent for the company notifying them of the problem and ask that the current parts are either replaced at no cost or refunded since the parts do not honor the contract. If there is no contract, then I would notify the company’s correspondent that there is an issue and, if it is not fixed, then I would seek out another company to do the same job.” (Skyler)

Another student mentioned that they would fine the supplier or put them on probation after alerting the supplier of the issue.

However, most students proposing to confront just described that their communication style would be particularly assertive. Their responses made it clear that they were approaching the situation with assumptions (that the supplier had changed the part) and a goal (for the part to meet specification again), rather than try to understand why the issue may be occurring. The following student response illustrates this idea:

> “[I would] plan out specifically what I want fixed and find a way to communicate those adjustments that is both respectful yet assertive. A meeting would be the best environment for this communication.” (Carey)

Although this student conveyed that they would want to be respectful in their communication, they also talked about directly confronting the supplier rather than keep an open mind about possible causes for the issue.

Switching to a New Supplier. Another popular approach for students, suggested by thirty-nine percent of students, was threatening to change suppliers if the supplier did not address the issue, or switching suppliers altogether, to get the desired result: "[I would] call a meeting with the supplier and tell them that if they can't get the parts right, then we will be forced to go to another supplier" (Toni). In these cases, students often expressed a preference for formal communication methods, rather than consider a more open approach:

> "I would submit a formal email to their [the supplier's] representative expressing the problem we were encountering. If no successful attempts are made for the product, I would change manufacturers." (Wren)

It was clear from student language that these communications, whether via email or in person, were intended to be more confrontational exchanges:

> "Make a visit with the head of the supplier in person to ask why they have strayed away from an agreement that was made previously. Tell them that they will be dropped as a supplier unless they revert back to their old size." (River)

Students seemed unaware that in some fields, especially those that are regulated, it would be difficult and time-consuming to switch suppliers.

Checking Assumptions. Eleven percent of students thought about the need to collect concrete evidence, further investigate the issue, or go through a process of "double checking" their assumptions before reaching out to the supplier. They suggested sending photos or other types of supporting data to the supplier as documented evidence of the issue. For example, one student stated:

> "You go back and look at the measurements of the product in the past and compare it with the ones you received recently. If they are the same size, you talk

> to your team and tell them they were incorrect. If they are [not] the same size, then you reach out to the supplier with proof that they aren't the same." (Ash)

In this case, the student considers that their product team may be incorrect. Students who checked assumptions also often paired this strategy with communicating with the supplier to better understand the situation:

> "I would greet them nicely, I would explain that the key component they sent is the wrong dimension and bring a blueprint/evidence of the correct dimensions and ask what is going on. From there on I would figure out what is the ideal solution that is mutually beneficial." (Reese)

This student specifically mentioned that they would communicate professionally and try to work with the supplier to reach a mutually beneficial conclusion, showing thoughtfulness in the way they would approach their interaction.

Updating Part. Seven percent of students proposed either updating the part's design specifications to accommodate the supplier's version of the part or creating the part in-house to avoid needing to rely on the supplier's part. Some of these students considered talking to the supplier to learn more about how they manufacture the part so that their company could manufacture the part itself as a first step:

> "[I would] talk to the supplier to get . . . an understanding of how to manufacture the part. If that doesn't work, redesign the product to fit the part that is being made. [I would] look into manufacturing the part for the product . . . or adapt the product to fit the new part." (Taylor)

For other students, this idea was a back-up in case other approaches they proposed did not work: "If [communicating with the supplier] fails, I would try to change the size of the part … so that it [the parts being provided by the supplier] can work" (Drew).

Combining Approaches. Seventeen percent of students proposed combined or multiple approaches to this scenario. For example, Dallas mentioned changing the supplier and the product design, stating, "My next steps would be to ask the supplier and whoever would be in charge of the department … why the part is not being shipped that size. If it's possible to get it in that size, then [I would] try to find [out] why … it was an issue in the first place. If it's not possible, then I would try to change supplier if the part is available elsewhere. If … that['s not possible], then I would try to develop the part in-house, if the part is easy enough to develop" (Dallas).

Student Responses to Scenario 2

The second scenario shared with students was based on the composite narrative "So I know this is not what you hired for. . .". In this scenario, an early-career engineer is hired for a job, but the project to which they are initially assigned is cancelled, and they now must work in an area they are less familiar with. The primary adaptability dimension emphasized in this situation is dealing with uncertain and unpredictable situations. Elements of interpersonal adaptability, learning new tasks, technologies, and procedures, and handling work stress are also present, as is a focus on adaptability balance.

Students were introduced to the scenario and asked how they would respond in the situation, and students once again provided a variety of responses. The most common responses revolved around seeking help from a mentor (43%), learning new skills independently (30%), and talking honestly about their situation with their manager (24%). Fewer students discussed considering leaving their job (19%) or translating their existing skills into their new role (14%). However, most student responses combined approaches to this scenario (56%).

Seeking Help from Mentor. Forty-three percent of students mentioned the importance of finding a mentor in this scenario to help learn the necessary skills related to their new job role. The types of mentors students would seek varied; some students described asking a peer on their team for help, and others said they would try to identify a more senior mentor within the organization. Students felt that their requests for help would be well received:

> “Ask your coworkers for help and to learn how to program this type of hardware. Asking for help in a situation like this shows your interest and desire to improve. [You have to] talk to people who are already doing the job and ask for help.” (Justice)

These responses were distinct from responses in which students described seeking help from a manager. They also often recommended a dual approach of seeking out mentorship while also teaching oneself independently:

> "[I would] reach out to coworkers or people in higher positions and ask for help on programming, [while] teach[ing] yourself the different skills required so that you can complete the job.” (August)

Notably, although many students mentioned that they would find a mentor who would be helpful to them, their responses lacked detail about the actual process they would use to secure mentorship.

Learning New Skills Independently. Thirty percent of students mentioned resources they would consult or utilize to learn the necessary skills related to their new job independently. These resources varied widely and included libraries, books, classes, YouTube, and other online resources. Student answers revolved around using whatever resources they could find: “[I would] do as much background research as possible into the new methodology. . . . Adaptability is all about utilizing your resources” (Stacey).

Talking Honestly with Manager. About a quarter of students (24%) proposed having an honest conversation with their manager in which they acknowledged their concerns with their new role, specifically, that their new project was outside their area of expertise and that they were uncomfortable with their job role changing and their needing to learn new skills. One student even stated they would explain their strengths and weaknesses and be honest about the feasibility that they could contribute to the project:

> "[I would] go to my manager and ask him for the training materials I need to learn the program, and if it is not a feasible task, I would explain to him my situation and ask him what to do next. I would explain to them my strengths and weaknesses. If they no longer see a need for me, then I will leave knowing I could do no help." (Justice)

Students hoped that their manager would take into consideration what they said and provide direction if they were honest about their skills:

> "[I would] be honest about the situation and explain how you could still contribute despite not having experience in hardware to the manager. I would inform the manager that I prefer software and that I would be more efficient at it. Hopefully, I would end up on software more often." (Taylor)

Justice and Taylor shared concerns about finding a suitable job-skill match within their organization in such a situation. As observed in the composite narrative on which this scenario was based, it seems likely that their manager would work with them to find a mutually beneficial outcome, rather than see them quit.

Considering Leaving Job. Nineteen percent of students said they would consider leaving their job if confronted with this scenario in real life. However, only a few (n = 3) students in this category offered applying for a new job or quitting as an immediate solution. Most students said they would consider this approach only if other strategies proved unsuccessful:

> "[I would] try to get as much experience out of it as possible, while also letting the managers know it is a bit out of your expertise. If it becomes too difficult, see if there are any other jobs at the same company, and if that doesn't work out, maybe find a new job." (Erin)

Similarly, students suggested that they would start conducting a job search on the side as they tried their best to succeed in their current role.

Translating Skills. Lastly, although not as popular as other responses, fourteen percent of students felt that the engineer's other skills and experiences could be translated to the current role to which they were assigned. As one student suggested:

> "I would do two things: find the relation[ship] … between creating software and programming a piece of hardware. . . . Although not exactly the same, your skills in software development helps [make] understanding the process of something like hardware programming much easier. [This does not] mean they are the same, it just means you'll have an easier time figuring it out than an aerospace engineer [would]." (Dakota)

In this example, the student mentions that there should be some transferrable skills or concepts between software and hardware programming and that identifying and leveraging them could be useful.

Another student shared a similar sentiment highlighting that the engineer translating their skills to their new context might even benefit the project by offering a new perspective:

> "If this happened, I would take what I know about developing software and apply it to the hardware project. Assuming that everybody else in my project specifically develop[s] hardware, I can give a different perspective." (Devin)

Combining Approaches. Most students (56%) proposed a combination of the approaches above for this scenario. They grasped the likelihood that they would have to combine (for example) learning independently, seeking mentorship, talking honestly with one's manager, and transferring their skills, as the following quote shows:

> "Ask for help, research how to do things, and try learning either from online or another person. Oftentimes people are going to be tasked with things they don't fully know, or people will have varying levels of confidence when it comes to certain tasks. I think just trying to learn how to use any skills you already know and pick up new ones in the hardware field is the best approach. Asking for help is also a good skill to have. If it's super hard to manage, request a little bit of patience while you pick up the new skills may be a good idea." (Elliott)

Comparing Student Responses to Scenarios

While the specific approaches students proposed to address each scenario are not meant to be compared – different responses are appropriate in different contexts – an evaluation of students' responses to the two scenarios did reveal two differences: (1)

students generally proposed more combined approaches to the second scenario than to the first scenario (56% compared to 17%), and (2) the order in which the first and second scenarios were presented generally seemed to influence student definitions of what it means for engineers to be adaptable post-intervention.

Regarding the first difference, several factors may help explain why students tended to propose, on average, one or two approaches for addressing the first scenario and multiple approaches for addressing the second. The second scenario, in which an engineer needed to navigate a new role, may have been imminently more accessible to students (who were navigating their first semester of engineering coursework themselves) than the first scenario, in which an engineer needed to navigate a part misspecification – a situation for which students might have not had a familiar frame of reference and, therefore, might find more abstract. The second scenario also focused on navigating a process involving primarily oneself, unlike the first scenario which focused on needing to interface with an external supplier. Further, students may have felt less of a need to explore the possible solution space in the first scenario based on assurances by the engineering team that the internal part specification had not changed; by contrast, the second scenario presupposed no solution, leaving the solution space arguably more open than in the first. Lastly, students might have been more generative in their proposed approaches to the second scenario because they understood from the first scenario that a variety of approaches could be valuable.

Regarding the second difference, the first and second scenarios were presented in reverse order in the second of three class sections to determine what, if any, influence their order had on student definitions of engineering adaptability post-intervention. A higher proportion of definitions from students in sections 1 and 3 mentioned dealing with uncertain and unpredictable situations than definitions from students in section 2, and a higher proportion of definitions from students in section 2 mentioned interpersonal adaptability than definitions from students in sections 1 and 3. Thus, students' definitions of adaptability post-intervention appear to have been potentially influenced by the last scenario to which they were exposed during the class activity.

With this pilot data alone, it is difficult to determine the full impact on the nature and order of scenarios on students' understanding of engineering adaptability, Repeating the intervention with more scenarios based on the composite narratives, therefore, represents a prime area for further investigation.

Student Post-Activity Reflections

After the scenario-based activity and a concluding presentation on findings from the interviews with engineering managers, students were assigned to reflect on the following questions: (1) How has your understanding of adaptability changed (if at all) after learning about it in class?, and (2) Why and/or in what ways do you think adaptability is an important skill to the engineering workplace after learning about it in class?. These reflections provided further insight into what students learned from the activity, particularly related to adaptability in the engineering field.

Student reflections revealed six outcomes of the classroom activity: better understanding of engineering work, an expanded definition of adaptability, greater delineation of adaptability, increased self-awareness, an appreciation for adaptability balance, and enhanced feelings of job preparation. There was also a minority of students who reported no change in their understanding of adaptability because of the intervention, typically because they already had adaptability training or experiences. Examples of each type of reflection are provided below, followed by a synopsis of students' general impressions of the activity.

Better Understanding of Engineering. Twenty-five students mentioned gaining a better understanding of aspects of engineering work. For example, not all students were aware that the engineering field is constantly changing, necessitating engineers to adapt. One student wrote in their reflection that their parents' jobs appeared very consistent, requiring very little adaptability, and they had not considered that engineering may be different, which they called exciting and nerve-wracking:

> "I realized that not all jobs that you work for will always have you doing what you are used to. My parents have always done the same thing everyday at their job since they have worked there, so I guess I always figured each job had you doing for the most part only one thing. This excited me in that I will have chances to try out different things and learn to adapt to different jobs. It also can be nerve-racking because you may not have the chance to do what you really want in some situations, but I know you can always change that yourself. I think adaptability is very important in this situation, as engineering is not always so consistent with its work type, so you need to learn how to do different types of job work." (Dakota)

Some students in this category had also been previously unaware of the transdisciplinary nature of the field which requires engineers to communicate and trade information with different stakeholders:

> "At first before starting the class, I had thought each section of the engineering [field] had done their own projects and research separately from one another; however, after spending more time in class doing projects and research, it slowly dawned on me that each pathway in engineering has the potential to work with each other and has many ideas that cross over into other fields, allowing for them to easily adapt to one another when working on projects with other disciplines of engineering. It is important to be able to adapt in the engineering workplace to allow for information to be shared [more easily] between those working on projects or a study." (Jessie)

Expanded Definition of Adaptability. Forty-four students reflected on how their definition for adaptability had expanded or changed. They expressed that, despite feeling like they knew what adaptability was before the class activity, they learned more about the areas in which an engineer needs to be adaptable. Overall, they believed their understanding of adaptability had become broader and more complex. More specifically, they realized that adaptability in engineering work does not involve only technical adaptability but also the less talked-about interpersonal, cultural, and work stress adaptability as well:

> "After listening to the presentation by Prof. [Sajadi], my opinion on adaptability has changed greatly. I now understand that adaptability is not just about the technical side of things, but it also refers to the interpersonal and mental aspect of working on a project and in a team. Adaptability includes understanding different perspectives as well as understanding how to handle adversity in both a technical and personal sense. Adaptability is very important in the engineering field, as engineers [being] able to change the direction of a project based on problems that arise, as well as understand the other members of their team on a personal level." (Emery)
>
> "Through today's class, I have begun to understand how crucial adaptability is to the engineering workplace. Originally, I believed that adaptability in engineering only had to do with problem solving. However, now I understand that certain scenarios of adaptability don't have to do with just solving a code or fixing a program. In fact, adaptability is much more about working with others and apply people skills to situations in which issues come up. Overall, I now believe that adaptability is crucial to working in any engineering job because so many unexpected scenarios can arise that require the ability to remain calm and solve the problem." (Pat)

Greater Delineation of Adaptability. Twenty-two students wrote in their reflections that, while the intervention had not changed their overarching definition of adaptability, it provided them the language to put their understanding to words. They also mentioned that the intervention gave them a better grasp on the specific component behaviors that make up adaptability and that they believed knowing what these behaviors were would help them identify which ones were potential areas for improvement in the future:

> "I think that the taught definition of adaptability was very similar to what I had in mind about the topic through real life experience rather than knowledge of the word. Having it fleshed out in class helped me understand that it is a skill that takes training and understanding as well as improvement in different areas." (Riley)

> "I do not think that my understanding of adaptability [has] necessarily changed after this class; however, I never thought about the broken-apart areas of adaptability that people undergo, which could really help me in the future to pinpoint where to focus on adapting." (Reed)

Increased Self-awareness. Sixteen students discussed the need for self-awareness related to adaptability. More specifically, they reported that the class activity helped them recognize that there were some areas of adaptability in which they were strong and other areas in which they should improve. One student reflected that they believed themselves to be very adaptable before the activity but now realized specific areas that they needed to work on:

> "Before class I had thought I was a very adaptable person. However, after learning about all the different aspects of adaptability, I have seen that I have some problem areas that I need to work on. It also emphasized just how important adaptability is for engineers and therefore my need to improve myself." (Robin)

Two other students talked about the need to be more open-minded to ideas and opinions outside of their own and suspend their biases when solving problems or interacting with other people – something that one of the students acknowledged as challenging:

> "I learned that perceived bias is a real issue when dealing with problems, and it's something I have to work on personally. Adaptability is an extremely important characteristic to have in engineering." (Noel)

> "My understanding of how much adaptability has to do with groups and the input of diverse opinions and personalities has really opened my eyes up to my own flaws. Especially because a vast background of knowledge from people with different perspectives is much better than the narrow scope of like-minded people in a similar situation. Not only working with others but also within yourself and how you deal with stressful situations too." (Skye)

Appreciation for Adaptability Balance. Thirteen students also picked up from the intervention the nuance in adaptability balance. For example, they conveyed that adaptability does not necessarily mean learning every new skill quickly because it might not always be possible – instead, it might require being strategic or working collaboratively with others to fill in the gaps in one's knowledge:

> "My understanding of adaptability changed after learning about it in class because now I believe that adaptability doesn't mean completely stepping out of your comfort zone and trying to learn every skill that you are unfamiliar with. After this class, I now understand that adaptability can mean taking on new challenges while staying in your general area of expertise. Being adaptable also means to experience humility and understand your limitations. Adaptability can also mean working with people who can do the work that you are unfamiliar with. This kind of adaptability can allow you to complete tasks that you would not be able to originally complete, due to the fact that you recognized your own limits." (Sloane)

Other students in this category discussed the need to balance both working well with other people (interpersonal adaptability) and managing one's own emotions (handling work stress) for optimal work performance. One student mentioned, "I am now considering more that some issue that you need to adapt to are not always from an external source." (True) Another student elaborated on this idea, offering:

> "You have to be able to internally adapt to things and deal with how it affects you individually. And you also have to be able to adapt to other people and work well with them, because working well with others will heighten the overall work that gets done." (Spencer)

Enhanced Job Preparedness. Fifteen students reported that the scenarios supplemented their understanding of situations to which they might need to adapt as an engineer, which, in turn, helped them feel better prepared for the engineering workforce. Students described how they would continue to apply the lessons from the class activity to their work practice in the future:

> "My understanding of adaptability has changed after this class through the activities where I placed myself in the shoes of someone in the workplace and tried to problem solve when things didn't go my way. This helped me understand how I would approach different problems and helped me learn about my own adaptability skills." (Perry)

> "My understanding of adaptability has completely changed as I didn't think that there were various versions of adaptability. These newly learned definitions have provided me with great insight as to what to expect in the engineering workplace. I now know the skills that it takes to be able to adapt in any given situation by relating the presentation practices to the dimensions of adaptability. These definitions will carry on with me and be continuously applied to all occurring circumstances." (Phoenix)

No Change. Twenty-three students expressed that their definition for or understanding of adaptability had not changed at all as a result of the intervention. These students explained that they had learned about the topic before (e.g., in their high school classes or extracurricular activities) or had past life or work experiences that they felt had reinforced the importance of adaptability already. Students sometimes spoke of having had a combination of these experiences:

> "My understanding of adaptability has not changed much through this class because all of the situations that were mentioned in the presentation I had been faced with in an engineering setting whether that be in a robotics club or through work experience." (Sage)

> "I've spent my entire life adapting, and it's a part of me. I don't think my understanding of adaptability changed due to my life experiences." (Wynn)

General Perceptions of the Classroom Activity

Overall, the scenario-based activity was positively received by students – they expressed enjoyment from interacting with the workplace scenarios and seeing specific examples of what could happen in the engineering workplace:

> "During this presentation, I was able to gain a deeper understanding of the different kinds of adaptability in the engineering workforce, which I had never really thought about before. I really liked the workplace scenarios because it brought up some points I had never thought of before. This makes me feel better prepared to apply these tactics to my future. It is clear that adaptability is an important skill in the engineering workplace because it helps employees do better in uncertain situations." (Payton)

Based on the expanded definitions and enhanced preparedness students mentioned, it seems that many believed that they could become more adaptable over time, that they had experienced growth in adaptability during their lifetimes, and that they would continue to develop their adaptability into the future. Along these lines, one student in their reflection compared adaptability to growth mindset and endorsed adaptability as a learnable skill important for all engineers to have:

> "My take on adaptability when I was younger was that all people naturally have this talent and will continue to have it for the rest of their life. This can be true to some extent, but it's something that can be learned. I am exhibit A of this statement because it's [also] something that I've been learning over the years, and here at [University]. It's nowhere near perfect or where I want it to be, but I know it will get better, especially in this industry. These are fundamental skills as an engineer, and it is very important to learn them so that these problems are second nature to them in the long run." (Florian)

However, some other students (four) felt similarly to Manager 17 and one wrote that adaptability is not necessarily something that can be taught, stating: "I feel like it [adaptability] is a skill you do or don't have. However, I did learn more about the … environments you can use it in [if you do have it]" (Windsor).

Of the 158 reflection responses, only a single student mentioned disliking parts of the class activity, specifically, the second scenario based on dealing uncertain and unpredictable situations. In each class, alternative endings to the scenario were discussed, including that it might be appropriate to leave the company or push back against the organization. Some students specifically wrote about these ideas in their reflections. This student shared in their reflection the opinion that too many organizations are putting early-career engineers in difficult and imbalanced situations unnecessarily, saying the following:

> "Teaching students this now will result in them being weaker employees that will be hired for one thing, have their job title switched and their pay lowered, and then thank the business for giving them this kind of 'enlightening and different' opportunity. . . . While I definitely agree that adaptability in almost every other situation is good, applying it to the engineering workforce and future employees results in a toxic position between employers and employees. Why should an employer hire many different people for a project if they can just hire one that can 'adapt' to everything and learn all of it outside work for no substantial pay increase? No thanks; who's to even say if that all of that new information will be useful in other jobs anyways? What if you need to 'adapt' to using a worse software because a company refuses to upgrade, or you need to 'adapt' to working with a worse material because the company wants it." (Harley)

In this excerpt, the student is concerned with an employer expecting them to learn new software which may not useful to them in the long run or to perform additional tasks without increased pay, a situation which they describe as "toxic." Notably, there was no discussion of pay in the referenced scenario nor was it specified that learning would have to be done outside of the workplace, and only this student interpreted the scenario in this way. However, their response is highlighted here because it serves as a reminder, reiterated through this dissertation, of the importance of emphasizing adaptability balance and context when teaching about adaptability. That is, students should be trained to think about adaptability as not about being flexible to any change but about recognizing when the impetus to adapt (e.g., from the organization or the environment) requires pushing back. E.g., in response to Scenario 2, students discussed the need to petition for a change, switch companies, or (as one student put it) "writ[e] a hearty

Glassdoor review" (a job review website). For employers' part, situations like the second scenario came up multiple times in the relatively small sample of managers in this dissertation; it is just as imperative for employers to consider their own practices to try to avoid situations like the second scenario as it is to prepare students to be adaptable.

Discussion of Classroom Activity

The results of the scenario-based classroom activity suggest that efforts to help students develop a more complex and sophisticated definition of adaptability in the engineering workplace were generally successful. Students' definitions of adaptability changed after engaging with the two scenarios to become more multidimensional and reflective of the aspects of adaptability emphasized in the scenarios (i.e., interpersonal adaptability, and dealing with uncertain and unpredictable situations). Further, student responses to the written reflection after the activity provided additional evidence for students' increased knowledge and awareness of adaptability as an important skill for engineers to have. These results support engineering managers' hypotheses (as expressed in the qualitative interviews) that specific types of experiences can increase individuals' adaptability, or at least their understanding of it. Some students even seemed to develop increased self-awareness around their own adaptability. Scenario-based learning, therefore, appears to be an impactful means to integrate learning about adaptability and its nuances into the engineering curriculum.

Students' definitions of adaptability mirrored those managers provided in their interviews for the most part. I.e., all six dimensions of adaptability identified in the interviews with managers were present across student's definitions, both before and after engaging with the scenarios, albeit to different extents. Students' responses to the scenarios also reflected some of the concerns engineering managers had engineers adapting to various situations. For example, although adaptability is often associated with flexibility, both managers and students clearly articulated that adaptability is about mutually beneficial success for the individual and organization rather than just blind assimilation. Each group discussed the need to balance, how, when, and to what extent engineers should adapt in several contexts and scenarios. They also described adaptable engineers as willing to push back against untenable circumstances (e.g., sexism, racism) and use their awareness of the field and their skills to best position themselves for success and meaningful impact.

At the same time, gaps existed between students' responses and what managers expressed had happened or should have happened in the situations on which the scenarios were built. Understanding these gaps provides additional evidence for why explicit instruction in adaptability development for students might be helpful. For example, the manager whose interview response primarily shaped Scenario 1 specifically discussed warning their engineer against being too confrontational with the supplier about the sudden change in part specification. Instead, they recommended that the engineer stay open-minded, check their assumptions, approach the supplier in a way that respected the existing relationship, and work together with the supplier to find a solution rather than cast blame. In this specific example, taking this approach was especially important since the engineers' initial assumption, supported by the information given to them by their engineering team, ended up being wrong. When presented with this scenario as part of the classroom activity, many students' answers tended to run contrary to the manager's suggested approach. "Assertive" or "direct" approaches such as immediately changing suppliers or confronting the supplier about the part change were popular. Relatively fewer students suggested taking a more open-minded or collaborative approach with the supplier, nor did they emphasize that they would try to communicate in an understanding way. This disconnect between industry expectations for engineering graduates' communication skills and students' actual approaches to communication is supported by literature (Dannels et al., 2010; Donnell et al. 2011).

There is, thus, no doubt that the first-year engineering students who participated in the intervention are starting to build excellent foundations for developing adaptability. However, reviewing their responses reveals the utility of a scenario-based activity where an instructor can begin to discuss the mechanics of what proper adaptability looks like. Discussing such scenarios with students may help them overcome some of their biases and assumptions, such as regarding communication with different audiences, and help clarify what responses may be most appropriate for the various situations they will encounter as engineers in the future. Scenario-based learning has been found to improve adaptability-related skills in contexts both within (McKenna, 2007) and outside (Duffy, 2010; Granziera & Martin, 2016; Salas et al., 2006) of engineering. Similar methodologies, such as game-based learning, have shown utility for improving engineering students' adaptability and related skills (e.g., interpersonal communication; Bodnar & Clark, 2017), as well.

Summary and Synthesis

Several findings emerged from this investigation of adaptability in the engineering field:

1. **Engineering adaptability includes six behavioral dimensions.** In the qualitative critical incident interviews with engineering managers, the following dimensions of adaptability were identified for an engineer to have: Creative Problem Solving; Interpersonal Adaptability; Handling Work Stress; Dealing

with Uncertain and Unpredictable Situations; Learning New Tasks, Technologies, and Procedures; and Cultural Adaptability**.**

a. **Cultural adaptability is a critical dimension of engineering adaptability not previously associated with adaptability in technical work (NASEM, 2018).** Engineering managers frequently discussed cultural adaptability in the context of the increasing globalization of engineering work. They also mentioned the need to navigate a work across the cultures of different teams, functional units, and organizations.

b. **The definition of Learning New Skills, Technologies and Procedures has an emphasis on the idea of knowledge transfer for engineers.** Engineering managers emphasized the importance of not only learning new skills but also being able to apply them in the engineering context.

2. **Engineering adaptability depends on context and requires balance.** Engineering adaptability indicated that adaptability might look different depending on an engineer's career stage, job role, and work setting. Further, they emphasized that engineers must balance knowing when, how, and to what extent to be adaptable. I.e., it may not benefit an engineer to be adaptable under certain circumstances.

3. **Having self-awareness and specific kinds of experiences are crucial to adaptability.** Engineering managers highlighted that it is important that engineers possess self-awareness of their strengths and weaknesses to know in what ways they need to adapt in a situation. They also expressed that having

various experiences on which to draw can also increase an individual's likelihood of being adaptable.

4. **Multiple dimensions of adaptability are needed to navigate engineering situations.** Several composite narratives developed from the manager interviews depicted engineers drawing on multiple adaptability dimensions to address a problem or situation. Each of the six adaptability dimensions was thus found to be distinct but interrelated.
5. **Contextual support from managers and coworkers is integral to engineers' adaptability on the job.** The composite narratives also highlighted the importance of psychosocial and/or instrumental support from managers and coworkers in helping engineers navigate situations requiring them to adapt.
6. **Engineering students and engineering managers are aligned in their definitions of adaptability.** Students' definitions of adaptability before and after the scenario-based intervention reflected the same six adaptability dimensions identified in the interviews with engineering managers. Like the managers, students also discussed the importance of knowledge transfer.
7. **Gaps exist between how engineering students and engineering managers would respond to different engineering situations requiring adaptability.** Students proposed multiple approaches to the scenarios presented during the classroom intervention, some of which managers described in their interviews as less effective than other possible approaches.
8. **Students' definitions of adaptability can become more complex and sophisticated after a scenario-based classroom intervention.** Students' definitions became more multi-dimensional after engaging with the scenarios as

part of the intervention. Many students reflected that the activity helped expand their perceptions of adaptability and was beneficial.

The findings above address this dissertation's goal of understanding adaptability in several ways. First, this work makes a theoretical contribution to the literature by tailoring an existing workplace adaptability framework (Pulakos et al., 2000) to the engineering field. This engineering-specific version of the framework can be used to further investigate engineering adaptability and foster specific attributes of adaptability among engineering students. Engineering managers also identified personal and contextual factors that might influence engineers' adaptability and adaptability development; these factors deserve additional research and teaching exploration as well. Second, this work further advances understanding of engineering adaptability by providing rich, texturized composite narratives rooted in the interviews with engineering managers and describing real-life situations to which engineers must adapt. These narratives can be useful for generation conversation about what engineers require to be adaptable with various stakeholders, including engineering students, educators, researchers, and policymakers. Third, few (if any) previous studies have implemented adaptability training in the engineering curriculum. The current study addressed this gap using a scenario-based classroom intervention. Analysis of student data indicated that their definitions of adaptability changed over the course of the intervention and that they were engaged throughout; thus, it can be concluded that the activity was effective in increasing students' awareness of the different ways in which they may need to be adaptable over their engineering careers.

This study was not without limitations. Data collection and analysis were chiefly qualitative and based on small sample sizes (i.e., 17 engineering managers and 149 engineering students). Therefore, the findings are not meant to be generalizable but to provide a starting point from which further work may be conducted. Additionally, data collection for this study occurred during the COVID-19 pandemic, which may have affected the results. All interviews with engineering managers were conducted virtually, and the scenario-based intervention was conducted with all individuals in the classroom wearing masks. Further, while the demographics of this study reflected those of the engineering field (i.e., mostly white and male), greater oversampling of women and people of color would have allowed for deeper understanding of how adaptability may be perceived similarly or differently based on demographic characteristics. Lastly, both the interviews with engineering managers and the scenario-based intervention with engineering students were situated in specific contexts (e.g., four engineering companies and one large public university, respectively). As such, findings from this dissertation should not be extrapolated to all contexts.

CHAPTER 5

CONCLUSIONS, FUTURE WORK AND RECOMMENDATIONS

The findings from this dissertation provide a deeper understanding of what adaptability means in the engineering field and how engineering adaptability can be fostered in the classroom.

Through qualitative critical incident interviews with engineering managers, support was found for six dimensions of adaptability (creative problem solving; interpersonal adaptability; handling work stress; dealing with uncertain and unpredictable situations; learning new tasks, technologies, and procedures; and cultural adaptability) originally identified by Pulakos et al. (2000) as critical for the workplace. Engineering-specific definitions for each adaptability dimension were created, and examples provided, in the form of quotes from the engineering managers and composite narratives based on their interviews. Further, managers identified personal (i.e., self-awareness, having had specific kinds of previous experiences) and contextual (e.g., career stage, job role, work setting) factors which they hypothesized influenced whether and how engineers were adaptable. They also emphasized the importance of adaptability balance in deciding to what extent an engineer should exhibit adaptive behaviors at all.

The scenario-based intervention on adaptability served as a foundation for how Pulakos et al.'s (2000) adaptability framework customized for engineering work can be brought into the classroom. First-year engineering students at a large public university were presented with and worked through what they would do in the case of two scenarios developed from the composite narratives. The scenarios gave students real-world examples of situations to which they might have to adapt as engineers in the future. In addition, the students reported that the intervention provided them with a better understanding of engineering work, an expanded definition of adaptability, greater delineation of adaptability, increased self-awareness, greater appreciation for the importance of adaptability balance, and enhanced feelings of job preparedness.

The remainder of this chapter focuses on recommendations based on the findings for employers, educators, and researchers.

Recommendation for Employers

The findings from this study can help engineering employers consider how to foster adaptability among their engineering workforce. Managers mentioned that training opportunities related to adaptability in their companies were insufficient to non-existent. One manager reflected that training opportunities in their company, in general, had declined over the years, while other managers reflected that employees often did not have time to participate in training due their high workloads, even when such opportunities were available. Training programs targeting engineers' adaptability development where they do not already exist could, therefore, prove useful.

Increasing the number of available training opportunities is also recommended, especially in the areas of cultural and interpersonal adaptability, where managers described that their engineers struggle. One manager reflected on how cultural competence training within their organization is often insufficient or outdated. Other managers shared the opinion that training related to cultural adaptability should focus on creating inclusive workplaces rather than requiring employees to assimilate to the dominant culture. Managers recommended specific actions that included adopting bias-free language, not requiring certain group to always accommodate other groups, and encouraging relationship-building and critical listening among employees. Cultivating these practices among engineers can help them exhibit more adaptability culturally and interpersonally, especially as their teams become increasingly diverse and global. Similar research has supported the importance of developing these same skills among engineering students (Gorodetskaya et al., 2015; Lanucha, 2018).Another opportunity to help employees foster adaptability is through the performance review process. A few managers mentioned that the performance review process could provide employees the opportunity to reflect and receive feedback on their progress toward developing and enacting adaptability in their role. Similarly, managers could also use this opportunity to help engineers identify work areas that align with their skills, interests, and values. Finding areas of alignment will intrinsically help engineers continue to adapt and grow, even in the face of change or challenges. Additionally, articulating alignments and gaps in expectations and identifying barriers to becoming more adaptable are skills that can help engineers foster greater adaptability. Given managers' comments about adaptability balance and context, it is also important for organizations to consider their own processes and procedures that may make it difficult for employees to effectively adapt. In particular, leaders must work to remove barriers and elevate catalysts to adaptability. Providing engineers with regular opportunities to update their skills and enabling engineers time to transition to new roles or changing workloads are just two ways in which employers could be more supportive of engineers' adaptability efforts. Engineering as a profession must adapt its culture to be more inclusive of top talent. Students are aware of resources like Glassdoor (a job review website) and may be considering what they learn from these resources in their job decision-making.

Recommendation for Educators

The study findings also demonstrate the promise of scenario-based learning for helping students learn about the different ways engineers must adapt on the job as well as reflect on their own adaptability. The scenario-based intervention used in this study focused primarily on two dimensions of adaptability, interpersonal adaptability and dealing with uncertain and unpredictable situations. Interpersonal adaptability was mentioned most frequently by managers and was an ideal starting point for this study; however, future iterations could introduce students to the other four dimensions of workplace adaptability discussed by engineering managers.

For example, managers highlighted the idea of knowledge transfer, especially in the school to work transition. Adapting what one had learned to new or different contexts was considered an important area in which engineers at all levels (including Ph.D. graduates) struggled. One manager attributed these struggles to some engineering programs' tendency to train students in a specialization early without adequate focus on how to transfer fundamental knowledge to various contexts. Students should be aware of how the content they can apply what the content and skills they are learning in class to real life. For example, instructors teaching students a specific CAD software can make students aware that, while there are other CAD packages they may need to use in the future, the underlying knowledge they are learning will allow them to transition to those packages more quickly and confidently. Students should also be aware that engineering problems have many possible solutions, some of which may differ from the textbook solution. Creating opportunities for students to test their learning in a hands-on way may help them further grasp these ideas. Importantly, the ideas of adaptability balance, context, and self-awareness are also key to teaching adaptability to students. Educators wishing to bring this activity into their classrooms are recommended to teach these topics together with the adaptability dimensions so that students develop a complete and nuanced understanding of adaptability. Explicitly helping students develop self-awareness and contextual awareness will also help them to foster adaptability—building self-awareness helps students identify what they need to adapt to and how to grow their skills in order to do so. This can be done through reflection activities and opportunities for constructive feedback when working in teams. It is important to note that intentionally scaffolding these feedback and reflection exercises to focus on a growth-mindset is important to their potential effectiveness. This can be used to support the scenario-based learning activities (Tilley et al., 2014). Additionally, including probing questions such as the ones included in this dissertation and discussion of alternate endings for each scenario can help greater student awareness of context and balance in each situation. These questions can act as a starting point for greater discussion on what adaptable behaviors look like, as well as a provide a safe space for students to learn about these ideas.

Lastly, while engineering educators are encouraged to bring the composite narratives generated in this dissertation into their classrooms, even if they do not, they can familiarize themselves with the narratives to be better informed and better able to prepare students for the kinds of situations that students will encounter in the workplace.

Recommendation for Researchers

The customization of Pulakos et al.'s (2000) workplace adaptability framework to the engineering field, and the composite narratives and scenario-based intervention stemming from this framework, contribute to the engineering literature and represent the first steps toward developing engineers who are more adaptable. Yet, despite these results, directions for future research remain. First, interviewing engineers from all career stages and demographic backgrounds will be necessary to gain a broader, more complete picture on the nature of adaptability in the engineering workplace. Context is also clearly important to adaptability. Studying engineers in different roles and companies would help to capture some of these contextual differences. For example, working in a heavily regulated industry such as healthcare or aerospace engineering may require different types of adaptability than working in a less regulated industry. Organizational contexts that may shape the catalysts and barriers to engineers' workplace adaptability deserve further consideration as well.

Second, more work is needed to understand adaptability at the engineering team and organizational levels. The adaptability literature, including Pulakos et al. (2000), explicitly discusses and differentiates between individual, team, and organizational adaptability. Future work can expand on the study of individual adaptability to understand the adaptability of engineering teams and organizations and how adaptability at these different levels influences and interrelates with one another. Further understanding at all these levels will be needed to foster adaptability sustainably in the engineering field.

Third, developing a deeper understanding of adaptability training and its effectiveness is another area for future exploration. Examining both wise (Walton & Wilson, 2018) and longer-term interventions could provide data on what types of interventions are best for teaching adaptability. Longitudinal and/or mixed methods data on the effectiveness of these activities are also an area of future interest; such work could include the development of both affective and behavioral-based instruments with which to measure changes in adaptability. Further, creating e-learning or augmented/virtual reality tools that offer these types of scenario-based interventions to students at scale could be another area of future study.

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APPENDIX A

MANAGER INTERVIEWS IRB APPROVAL

ASU Knowledge Enterprise Development

EXEMPTION GRANTED

Samantha Brunhaver
IAFSE-PS: Polytechnic Engineering Programs (EGR)
480/727-1883
Samantha.Brunhaver@asu.edu

Dear Samantha Brunhaver:

On 2/9/2022 the ASU IRB reviewed the following protocol:

Type of Review:	Modification / Update
Title:	Ready for Change: Fostering Adaptability along the Engineering Pathway
Investigator:	Samantha Brunhaver
IRB ID:	STUDY00012291
Funding:	Name: National Science Foundation (NSF), Funding Source ID: FP00020658
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Interview Protocol Phase 2.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • IRB Protocol Updated.docx, Category: IRB Protocol; • Recruitment Emails Phase 2.pdf, Category: Recruitment Materials; • Research Information Sheet Phase 2.pdf, Category: Consent Form; • Screening Survey Phase 2.pdf, Category: Screening forms;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 2/9/2022.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

REMINDER - - Effective January 12, 2022, in-person interactions with human subjects require adherence to all current policies for ASU faculty, staff, students and visitors. Up-to-date information regarding ASU's COVID-19 Management Strategy can be found here. IRB approval is related to the research activity involving human subjects, all other protocols related to COVID-19 management including face coverings, health checks, facility access, etc. are governed by current ASU policy.

Sincerely,

IRB Administrator

APPENDIX B

MANAGER INTERVIEW PROTOCOL

Interview Protocol #1: Managers
This interview will utilize the semi-structured protocol, as seen below. This protocol aims to collect engineering managers' views about adaptability in engineering and reflections on specific times when engineers have had to adapt on the job. Managers will be asked to describe for each incident the: (1) circumstances surrounding the situation, (2) actions and reactions of the engineer, (3) problems the engineer encountered and resources the engineer used or sought, and (4) outcome of the situation, including the manager's appraisal of why the engineer was successful or unsuccessful and what the engineer could have done differently. Each manager will also be asked how adaptability varies across engineers, how their organization helps foster adaptability, and how adaptability influences hiring and promotion decisions. Participants will be emailed the research information sheet and the interview protocol ahead of the interview.

Introduction

- Hi, how are you today? *(Wait for reply.)*
- Thanks for taking the time to participate in this interview. As I mentioned in my emails, I am interested in hearing your perspectives on adaptability, in general and especially related to the early-career engineers you supervise.
- You received the research information sheet ahead of the interview. Do you have any questions or concerns before we start? (*Respond to questions/concerns.)* Do you consent to being interviewed and having this interview audio recorded? (*Wait for reply.)*
- Great, let's jump in. As a reminder, you don't have to use the actual names of people or projects when answering these questions, but we'll anonymize any identifying information you tell us in the interview transcript.

Questions

My first few questions are meant to collect some context for the interview.

1. Can you tell me about your role and where you sit within the organization?
2. How long have you been in this role?
3. How large is the unit or team you manage? How many are new or early-career engineers?
4. Where do the new or early-career engineers [in your unit/on your team] typically come from, in terms of their degree program, degree level, graduating institution, etc.?
5. How much interaction do you have with these new or early-career engineers? *(E.g., are you their immediate supervisor, or do they report to your subordinates?)*
6. How would you describe the culture of your unit/team – what 2-3 things come to mind? *(Possibilities to probe: work values, norms, practices, etc.)* Is this similar or different to how you would describe your organization overall?

Now I'll be asking about your thoughts related to adaptability.

- What do you think adaptability means in the context of engineering work?

- What does it look like for an engineer to demonstrate good adaptability on the job? *(I.e., what mindsets, skills, and/or behaviors do they exhibit?)*
- What does it look like for an engineer to demonstrate poor adaptability on the job? *(Question could be played off of the interviewee's previous response, e.g., "So if good adaptability is XYZ, what does poor adaptability look like?".)*
- Where do you think adaptability comes from? *(I.e., why are some people adaptable, and others not?)*
- Thinking about your engineers' different backgrounds and experience levels, have you noticed any trends in who is more or less likely to be adaptable?
- What challenges or barriers to adaptability do you observe among your engineers?
- Does your organization offer training/support to help engineers become more adaptable?
- How does a prospective engineer's adaptability factor into hiring decisions for your unit?
- How does an engineer's adaptability factor into promotion decisions for your unit?

For this next part, I'd like you to think back on times over the past year when an engineer under your supervision had to be adaptable. This could include a new or early-career engineer, an experienced engineer, or an intern. It doesn't matter whether the outcomes of these situations were positive or negative. I'll ask you specific questions about each one. Let me know when you have one clearly in your mind.

<table>
<tr>
<td>These questions will be repeated for each of the 2-3 scenarios shared by the participant.</td>
<td>
1. What were the general circumstances leading up to this situation?
    1. How did the engineer come to be in that situation? (E.g., why were they given that assignment?)
    2. In what ways did the situation require them to adapt?
2. How did the engineer react to the situation?
    1. What actions or strategies did they take?
    2. What were their mindsets or emotions like?
    3. If interviewee does not describe a specific reaction, probe about whether the engineer seemed:
        1. Concerned about (i.e., invested in) the situation
        2. In-control of the situation
        3. Curious to understand more about the situation
        4. Confident in their ability to handle the situation
Did they face any challenges or barriers, and if so, how did they approach them? Did you notice if they sought out or availed themselves of any resources?
</td>
</tr>
</table>

	How did you see your role in this situation? What role did other people play, if any? What was the outcome of the situation? *(E.g., did the engineer finish out the project, get assigned to a new project, etc.)* . What do you think the engineer did well? a. What could the engineer have done differently?

Let's move on to another time within the last year when an engineer under your supervision had to be adaptable. Again, this could be a new or early-career engineer, an experienced engineer, or an intern, and it doesn't matter whether the outcomes of these situations were positive or negative. I'll ask you specific questions about each one. Let me know when you have one clearly in your mind.

Repeat Question 3 one time with the following considerations.	We hope interviewees will touch upon, either directly or indirectly, all or most of the following scenarios: 1. Creatively solve problems 2. Adjust to uncertain or unpredictable situation 3. Learn new knowledge and skills quickly and enthusiastically 4. Remain open-minded and flexible in interpersonal interactions (e.g., collaborating with those who have different opinions, accepting and responding to feedback, etc.) 5. Remain calm when handling work stress (e.g., unexpected challenges, high workload) If an interviewee does not address a particular scenario and there is still time, ask if they can think of a time when that scenario occurred. For example: • Has there been a time where you've seen an engineer have to adapt to a large workload or stressful situation? Can you tell me about that? • How about when employees need to learn something new – have you observed adaptability in those situations? What did that look like? Attempt to collect both a positive incident and a negative incident. If the interviewee provides one (positive or negative), ask them if they can provide an example of the other.

	Ask the interviewee if they have any incidents that happened before Covid-19 they can share if they start with one that happened during Covid-19.

My last few questions touch upon changes happening now and in the future.

1. What influence has Covid-19 had on engineers in your unit, and particularly, your new and early-career engineers? Can you provide specific examples?
2. Looking ahead, how do you see engineering work in your industry changing? In what ways do you think engineers in your industry will need to adapt? *(Possibilities to probe: future technologies, globalization, digitization, etc.)*
3. What changes do you think are needed for your industry to continue adapting? *(Possibilities to probe: the need for greater numbers and/or diversity of engineers, the need for specific technologies to be developed or problems solved, etc.)*

Is there anything else you would like to add that we haven't covered?

Conclusion
Thank you so much for your time! We appreciate you sharing your perspectives with us. Do you have any questions for me before we wrap up? *(Answer questions; offer to follow up with any information not immediately at hand.)*

APPENDIX C

CLASSROOM INTERVENTION IRB APPROVAL

EXEMPTION GRANTED

Samantha Brunhaver
IAFSE-PS: Polytechnic Engineering Programs (EGR)
480/727-1883
Samantha.Brunhaver@asu.edu

Dear Samantha Brunhaver:

On 11/29/2021 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Understanding First Year Engineering Student Adaptability
Investigator:	Samantha Brunhaver
IRB ID:	STUDY00015011
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• AdaptabilityReflectionWorksheetContent.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • ConsentForm_AdaptabilityActivity_Updated.pdf, Category: Consent Form; • IRB Social Behavioral_AdaptabilityPilot_Updated.docx, Category: IRB Protocol; • Mail - Susan Sajadi (Student) - Outlook.pdf, Category: Off-site authorizations (school permission, other IRB approvals, Tribal permission etc); • Powerpoint for Guest Lecture , Category: Other;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (1) Educational settings on 11/29/2021.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

REMINDER - All in-person interactions with human subjects require the completion of the ASU Daily Health Check by the ASU members prior to the interaction and the use of face coverings by researchers, research teams and research participants during the interaction. These requirements will minimize risk, protect health and support a safe research environment. These requirements apply both on- and off-campus.

The above change is effective as of July 29th 2021 until further notice and replaces all previously published guidance. Thank you for your continued commitment to ensuring a healthy and productive ASU community.

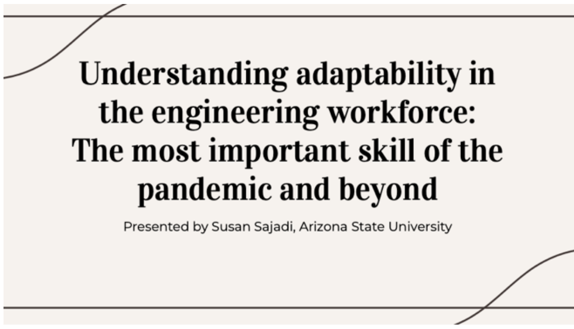
Sincerely,

IRB Administrator

cc: Susan Sajadi
Susan Sajadi

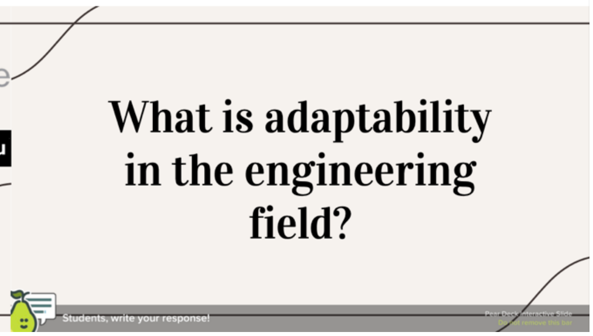
APPENDIX D

PRESENTATION SLIDES


Understanding adaptability in the engineering workforce: The most important skill of the pandemic and beyond
Presented by Susan Sajadi, Arizona State University


Engineering Experience
PHOENIX CHILDREN'S
GORE
Hanger


Education and Corporate Social Responsibility Experience
verizon
innovative learning
epics@asu


What is adaptability in the engineering field?
Students, write your response!

Scenario 1:

A supplier for a key part of your product is no longer meeting specification. The part is no longer the correct size, and it crucially impacts your design. They had been meeting specifications previously. Your team has tasked you with communicating with the supplier.

Question: What are your next steps and why?

Students, write your response!

Outcomes

- The issue was actually related to a design change at your company
- There is a need for a new supplier or to make the product in house
- There is a miscommunication
- The product needs to be re-designed

Scenario 2:

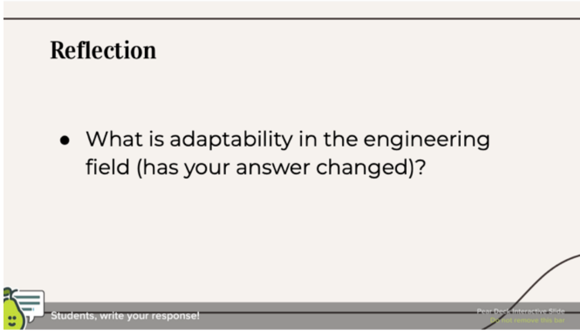
You just got an engineering job. The job is related to an engineering project you did in school, so you are excited to bring your experience to the project. Two weeks after your start, the project you were supposed to work on is shut down. Your managers tells you that you will be working on a new project. You realize that this project requires you to apply your skills in a way you have never before—your experience is in developing software, but have never programmed hardware as this project requires.

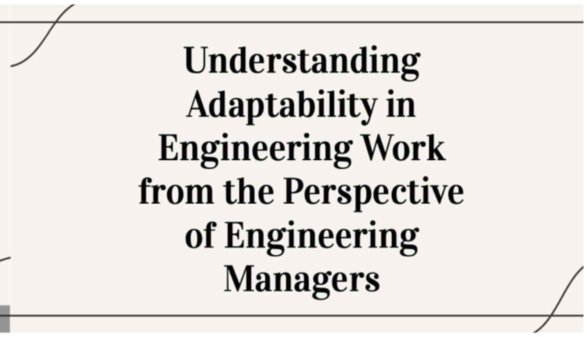
Question: What are your next steps and why?

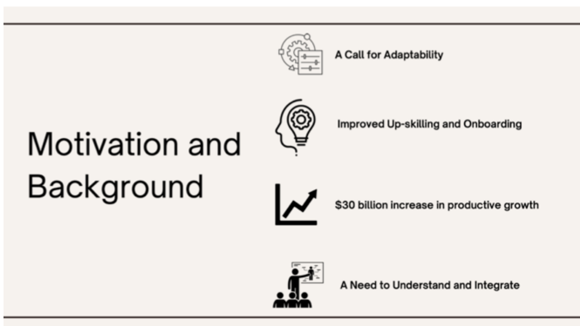
Students, write your response!

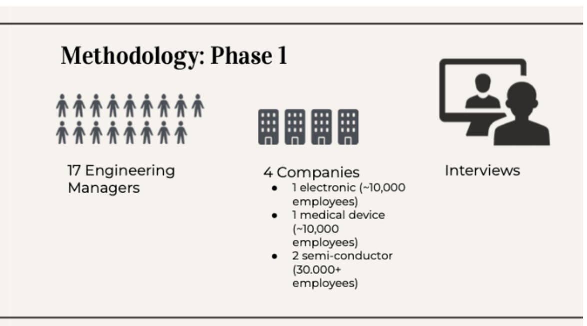
Outcomes

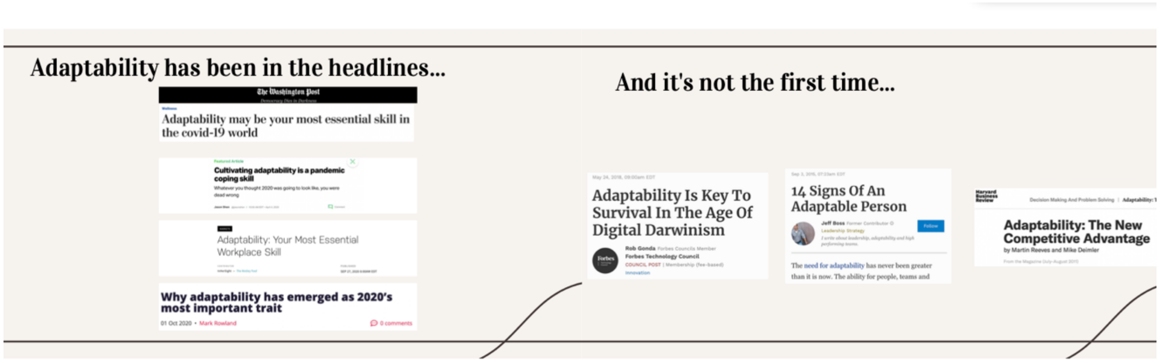
- You work on the new team, but eventually ask your manager to help you get back to what you were originally hired for
- You enjoy the new work and thrive in that direction
- You leave the company to work in the area you have interest in

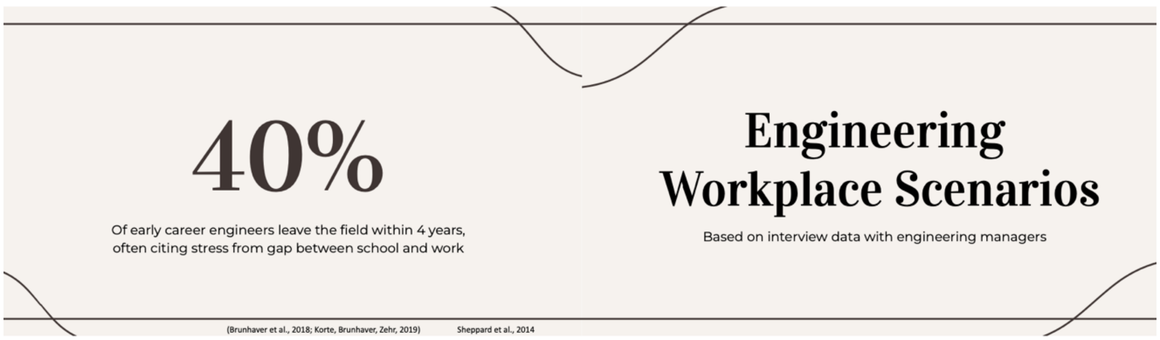

Reflection
What is adaptability in the engineering field (has your answer changed)?
Students, write your response!

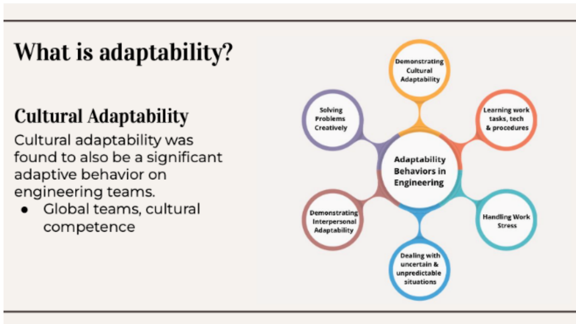

Understanding Adaptability in Engineering Work from the Perspective of Engineering Managers


Motivation and Background
A Call for Adaptability
Improved Up-skilling and Onboarding
$30 billion increase in productive growth
A Need to Understand and Integrate

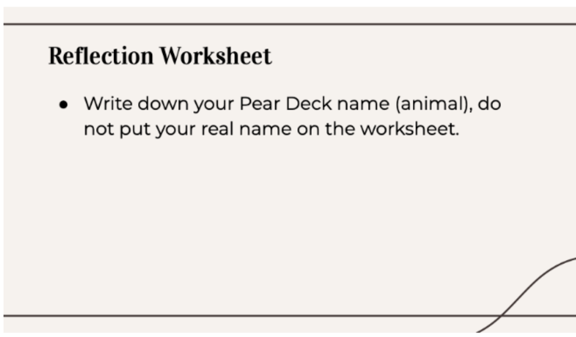

Methodology: Phase 1
17 Engineering Managers
4 Companies
1 electronic (~10,000 employees)
1 medical device (~10,000 employees)
2 semi-conductor (30,000+ employees)
Interviews

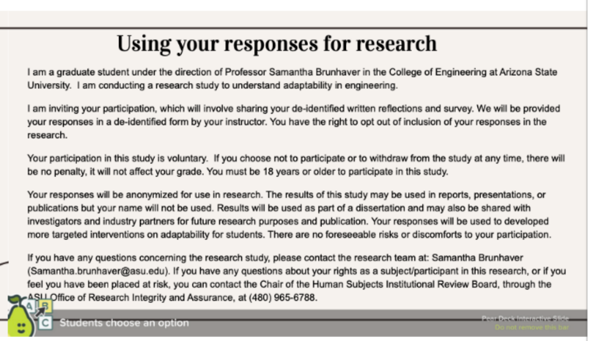

Adaptability has been in the headlines...
The Washington Post
Adaptability may be your most essential skill in the covid-19 world
Cultivating adaptability is a pandemic coping skill
Adaptability: Your Most Essential Workplace Skill
Why adaptability has emerged as 2020's most important trait
01 Oct 2020 • Mark Rowland
And it's not the first time...
Adaptability Is Key To Survival In The Age Of Digital Darwinism
14 Signs Of An Adaptable Person
Adaptability: The New Competitive Advantage
by Martin Reeves and Mike Deimler

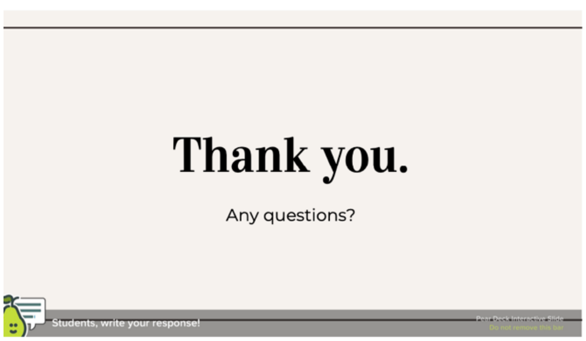

40%
Of early career engineers leave the field within 4 years, often citing stress from gap between school and work
Engineering Workplace Scenarios
Based on interview data with engineering managers
(Brunhaver et al., 2018; Korte, Brunhaver, Zehr, 2019)
Sheppard et al., 2014


What is adaptability?
Cultural Adaptability
Cultural adaptability was found to also be a significant adaptive behavior on engineering teams.
• Global teams, cultural competence
Demonstrating Cultural Adaptability
Learning work tasks, tech & procedures
Handling Work Stress
Dealing with uncertain & unpredictable situations
Demonstrating Interpersonal Adaptability
Solving Problems Creatively
Adaptability Behaviors in Engineering


Self-Awareness
Knowing your skills and desires
"The problems are incredibly complex that we're working on and engineers that don't understand their strengths or haven't built relationships with people that compliment their weaknesses, are the ones that actually struggle a lot. You hear an expression... "Surround yourself with people that are smarter than you."you hear that, it's like, "Ah, you know, everybody is smarter than me in some capacity." But that's not the point. The point is you have weaknesses. Whether it's, you can't do program management, you don't understand the software side or whatever, build your team around your weakness"
-Nolan, Engineering Manager (Semiconductor)
"What are the new things I need to learn? What is the play of AI in this particular industry? Does that excite me or not?" And if it translates into, "I don't really care about software, I care about hardware," then, what does that hardware evolution actually look like?"
-Ida, Engineering Manager (Semiconductor)


Reflection Worksheet
• Write down your Pear Deck name (animal), do not put your real name on the worksheet.


Using your responses for research
I am a graduate student under the direction of Professor Samantha Brunhaver in the College of Engineering at Arizona State University. I am conducting a research study to understand adaptability in engineering.
I am inviting your participation, which will involve sharing your de-identified written reflections and survey. We will be provided your responses in a de-identified form by your instructor. You have the right to opt out of inclusion of your responses in the research.
Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty, it will not affect your grade. You must be 18 years or older to participate in this study.
Your responses will be anonymized for use in research. The results of this study may be used in reports, presentations, or publications but your name will not be used. Results will be used as part of a dissertation and may also be shared with investigators and industry partners for future research purposes and publication. Your responses will be used to developed more targeted interventions on adaptability for students. There are no foreseeable risks or discomforts to your participation.
If you have any questions concerning the research study, please contact the research team at: Samantha Brunhaver (Samantha.brunhaver@asu.edu). If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788.
Students choose an option


Thank you.
Any questions?
Students, write your response!