Engineering Leaders' Descriptions of Leadership Competencies in the Information Technology Field

Submitted by

Merri L. Pedersen

A Dissertation Presented in Partial Fulfillment

of the Requirements for the Degree

Doctorate of Education

Grand Canyon University

Phoenix, Arizona

July 31, 2020

GRAND CANYON UNIVERSITY

Engineering Leaders' Descriptions of Leadership Competencies in the Information Technology Field

by

Merri L. Pedersen

Approved

July 31, 2020

DISSERTATION COMMITTEE:

Mary Selke, Ph.D., Dissertation Chair

Tianyi Zhang Ulyshen, Ph.D., Committee Member

Mark Bouie, Ed.D., Committee Member

ACCEPTED AND SIGNED:

Michael R. Berger

Michael R. Berger, Ed.D.
Dean, College of Doctoral Studies

7/31/20

Date

GRAND CANYON UNIVERSITY

Engineering Leaders' Descriptions of Leadership Competencies in the Information Technology Field

I verify that my dissertation represents original research, is not falsified or plagiarized, and that I accurately reported, cited, and referenced all sources within this manuscript in strict compliance with APA and Grand Canyon University (GCU) guidelines. I also verify my dissertation complies with the approval(s) granted for this research investigation by GCU Institutional Review Board (IRB).

Merri L. Pedersen ________________________ 7/26/2020

Merri L. Pedersen   Date

Abstract

The purpose of this qualitative descriptive study was to explore how engineering leaders describe the utilization of technical, human, and conceptual skills in their leadership positions in the information technology field in the United States. The research was based on the Katz (1955) three skills model for effective leadership. Three research questions were created, based on each skill, and answered via the Northouse Skills Inventory Survey (2018) and in-depth interviews. The overarching research question that guided the researcher in this study was how engineering leaders describe the utilization of technical, human, and conceptual skills in their leadership positions. The sample consisted of 23 engineering leaders for the surveys and 14 engineering leaders for the in-depth interviews. Data analysis of the surveys consisted of descriptive statistics. Interviews were analyzed using thematic analysis which generated six themes to address the research questions: 1) Technical background can be utilized without involvement in technical details; 2) Technical background can be utilized to solve problems and provide technical direction; 3) Emotional intelligence skills are utilized to manage social awareness, self-awareness, and self-management; 4) Relationship management skills are utilized for effective communication and interaction with others; 5) Seeing the big picture based on strategic and critical thinking skills can be utilized to solve problems and drive direction; 6) Encouraging innovation through the ability to create fortuitous interactions and understand the business. New ideas emerged on engineering leadership based on real-world leaders' descriptions of the three skills with an emphasis on emotional intelligence skills.

Keywords: Engineering leadership, information technology, Katz's three skills model, Emotional Intelligence, technical skills, human skills, conceptual skills.

Dedication

I dedicate this dissertation to my husband, kids, and my parents. To my husband, Randy, you have been by my side every day through this journey. You are my biggest cheerleader, my biggest fan, my sounding board, and the love of my life. Thank you for your non-stop support and allowing me to follow my life dream of becoming a doctor. I could not have done it without you. To my kids, Wendy and Erik, I have thought about you a lot throughout this process. I hope this dissertation serves as guidance for you that perseverance pays off. You have become wonderful adults and I expect great things from you. To my parents, Ray and Shirley Tanner, I dedicate this dissertation to you and thank you for your support and confidence in me every day of my life. Mom, although you are not with us anymore, the picture of you in my office was a constant reminder of how you used to tell me that I should write a book someday – well, here it is! Dad, I am your father's daughter and am so much like you. I appreciate your support and encouragement throughout my doctoral journey.

Acknowledgments

This doctoral journey and dissertation are one of my biggest life accomplishments. I would not have been able to complete it without key people in my life. Thank you to my family and friends who supported me and gave me time to research, read, and write for the past four years. I could not have done it without your support. Thank you to my colleagues at GCU – your encouragement and support was invaluable. Thank you to my chair, Dr. Mary Selke, who was an amazing teacher with the ability to provide feedback and direction that not only helped me as a learner but turned me into a scholar. To my methodologist, Dr. Tianyi Zhang Ulyshen, you were meticulous when reviewing my study which was so valuable every step of the way. Thank you to my whole committee for your guidance and support throughout my dissertation process. Finally, I would like to acknowledge Dr. Wayne Schmidt. You were my first professor in my first doctoral class, and you have had an ongoing impact on my dissertation journey. I will never forget the advice and guidance that you provided our cohort class – read, read, and read some more. You were upfront about the amount of work and dedication it would take to get through this process, and you were right, it took every ounce of tenacity and perseverance to get through this journey – but it was worth it – I will forever be known as Dr. Pedersen.

Table of Contents

List of Tables

Chapter 1: Introduction to the Study

Introduction

The field of information technology has become an integral part of organizations to support the fast-changing global business world. Within the information technology field, engineering leaders play a key role in delivering results to customers through new ideas and technological advances (Perri, Farrington, Johnson, & O'Connor, 2019). Information technology is a broad field consisting of professionals who are focused in areas such as software development, systems analysis, network administration, database administration, and numerous other technology-focused disciplines (Beckhusen, 2016). The need for skilled engineering leaders continues to increase due to the tenfold growth in the information technology workforce since 1970 (Beckhusen, 2016). Within the many disciplines of the information technology field, engineering managers are one of the largest groups (Beckhusen, 2016). As technology continues to expand, so does the role of engineering leadership.

Leaders in the technical world of engineering are challenged with fast-changing technologies, understanding the conceptual aspects of the business, and communicating effectively with others in the organization. The evolving world of technology will continue to put pressure on leaders within the information technology field to modify their role and skillsets (Williams, 2016). Capretz and Ahmed (2018) discovered that people moving into engineering leadership positions struggle with the human aspects of the role. The technical aspects of engineering may be predictable and logical, yet human skills and conceptual skills are less predictable (Capretz & Ahmed, 2018). Kalliamvakou et al. (2017) posited that technical skills were not as important in engineering leadership positions, yet Rottmann, Reeve, Sacks, and Klassen (2016) indicated technical skills were needed in engineering leadership. Thus, there are discrepancies in the literature on the importance of technical skills in engineering leadership which needs further investigation.

As the world becomes more reliant on technology advances, the skills of engineering leaders continue to change. The changes in engineering leadership skills also impact engineers who are transitioning to leadership roles. Perry, Hunter, Currall, and Frauenheim (2017) noted the need for future engineering leaders to have a variety of skills which may include technical, innovation, and leadership skills. Future engineering leaders may also need to develop social, human, and conceptual skills (Boyatzis, Rochford, & Cavanagh, 2017; Harrison, Burnard, & Paul, 2018; Racine, 2015). The skill set needed for engineering leadership is unique due to global competitiveness, innovation, and advances in technology (Perry et al., 2017), so it is valuable to understand the competencies utilized by current engineering leaders to help prepare upcoming leaders.

In this qualitative descriptive research study, the researcher focused on describing how engineering leaders utilize technical skills, human skills, and conceptual skills in their leadership positions. A description of how engineering leaders utilize technical skills, human skills, and conceptual skills in engineering leadership was needed to improve engineering leadership (Boyatzis et al., 2017; Kalliamvakou et al., 2017; Medcof, 2017; Racine, 2015; Rottmann et al., 2016).

Researchers have investigated aspects of engineering leadership from many perspectives such as considering the utilization of technical skills, human skills, and conceptual skills. There are discrepancies in findings and lack of descriptions from real-world engineering leaders, which has led to the suggestion for continued research (Capretz & Ahmed, 2018; Kalliamvakou et al., 2017; Perry et al., 2017; Rottmann, Sacks, & Reeve, 2015). Discrepancies in the existing literature on the utilization of technical skills in engineering leadership positions suggested a need for additional research (Kalliamvakou et al., 2017; Rottmann et al., 2016). Researchers have also considered the utilization of human skills in engineering, but the samples did not include engineering leaders (Boyatzis et al., 2017; Rottmann et al., 2016).

There is limited research on the utilization of conceptual skills within engineering leadership. Kearns, Livingston, Scherer, and McShane (2015) considered the utilization of conceptual skills in leadership positions by using leaders of 20 non-profit organizations as the sample for the study. While the non-profit CEO's provided some insight into conceptual skills, Kearns et al. (2015) questioned if leaders in other organizations would have the same perspective. Capretz and Ahmed (2018) touched on the need for engineering leaders to utilize conceptual skills, such as seeing the big picture and noted the importance of continued research to understand skills needed in engineering leadership positions. Thus, there was a need to continue exploring how conceptual skills were utilized by engineering leaders.

While the existing literature has considered various aspects of leadership skills, there was still a need for additional research. Boyatzis et al. (2017) conducted a quantitative study to investigate the connection between interpersonal skills and effectiveness with engineers from a multi-national manufacturing company. Boyatzis et al. (2017) found a positive connection between interpersonal skills and an engineer's effectiveness but suggested further research was needed to validate the results. Kalliamvakou et al. (2017) utilized a mixed-method study with engineers and engineering managers to understand engineering leadership skills and suggested studying related perceptions within other organizations. Medcof (2017) summarized existing literature in the broad area of technology management to explain the utilization of leadership skills at different management levels and suggested further research due to discrepancies in the literature and the lack of research with technology leaders in organizations. Harrison et al. (2018) studied leadership skills through an entrepreneurial lens and concluded leaders need technical skills, human skills, conceptual skills, and entrepreneurial skills but suggested further work was needed to validate these claims. Rottmann et al. (2015) included entrepreneurial skills as an engineering leader skill and coupled it with the conceptual area of innovation.

The remainder of Chapter 1 includes an overview of the study, the background of the study, the problem statement, the purpose, and research questions. A summary of the study includes the significance of the study, the rationale for doing a qualitative methodology, and the nature of the descriptive design. A list of terms have been defined to provide the meaning of keywords utilized throughout the study. The final sections of Chapter 1 addresses assumptions, limitations, delimitations, as well as a summary of the chapter and the organization of the rest of the study.

Background of the Study

The background of the study was based on the need to explore how engineering leaders describe the utilization of skills in their leadership positions. The focus on understanding leadership skills was explored using Katz's (1955) three skills model of effective administration which included technical, human, and conceptual skills. Technical skills were defined as proficiencies or specialized knowledge within a specific discipline (Katz, 1955). Within the information technology field, there are numerous perspectives on the need for technical skills in engineering leadership positions such as specific methodologies, techniques, and technologies (Capretz & Ahmed, 2018; Kalliamvakou et al., 2017; Kearns et al., 2015; Medcof, 2017).

Katz (1955) defined human skills as the ability to work with others. Researchers have associated human skills with other terms such as soft skills which include collaboration, communication, and interpersonal skills (Capretz & Ahmed, 2018). Matturro, Raschetti, and Fontán (2015) studied the utilization of soft skills with engineering team leaders and identified skills such as communication, customer orientation, interpersonal, and teamwork skills as valuable in leadership positions. Katz (1955) identified conceptual skills as the ability to see the organization from a holistic perspective. Researchers (Kalliamvakou et al., 2017; Rottmann et al., 2016) suggested conceptual skills, such as problem-solving and driving alignment are needed in engineering. Conceptual skills are also tightly coupled with innovation from a vision perspective, trend anticipation, and calculated risk-taking perspective (Medcof, 2017; Rottmann et al., 2016).

Understanding the leadership skills within the information technology field was an ongoing concern among researchers (Kalliamvakou et al., 2017; Rottmann et al., 2015). For example, Rottmann et al. (2015) created a grounded theory of engineering leadership based on a qualitative study with engineers to identify key competencies in engineering leadership such as technical mastery, collaborative optimization, and organizational innovation. Rottmann et al. (2016) extended their research on engineering leadership, with a focus on engineers from various disciplines, but the sample in the study did not include engineering leaders.

Kalliamvakou et al. (2017) studied engineering leadership and discovered unexpected results in the perception of technical skills needed for information technology leadership, which contradicts the results found by Rottmann et al. (2016). In addition, Kalliamvakou et al. (2017) found the respondents, who consisted of engineers and managers, ranked technical skills lower than human skills and suggested expanding research into other engineering organizations to validate these results. Boyatzis et al. (2017) looked at soft skills and noted the significance of emotional intelligence in relation to engineering effectiveness but also did not consider the perspectives of engineering leaders.

While the researchers in these studies provided recommendations on competencies needed in leadership engineering positions, the samples consisted of engineers who were not in leadership roles; expanding the research to include engineers in leadership roles was a necessary next step (Boyatzis et al., 2017; Rottmann et al., 2016). Research was needed on how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions (Boyatzis et al., 2017; Kalliamvakou et al., 2017; Medcof, 2017; Racine, 2015; Rottmann et al., 2016). To address this gap in the literature, the research study was based on describing how engineering leaders utilize technical, human, and conceptual skills in engineering leadership positions.

Problem Statement

It was not known how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions. The population of interest was all engineering leaders within the information technology field in the United States. The unit of analysis was engineering leaders who were currently in leadership positions. The perspective of leaders in engineering was needed in the research literature (Boyatzis et al., 2017; Minh, Badir, Quang, Afsar, & Management, 2017; Rottmann et al., 2016). There has been a lack of attention on exploring engineering leadership within the engineering discipline in the information technology field. Research has shown that technical skills, human skills, and conceptual skills as important concepts to consider when looking at engineering leadership from an engineering perspective (Kalliamvakou et al., 2017; Medcof, 2017; Minh et al., 2017).

Understanding how engineering leaders within the information technology field in the United States describe the utilization of technical skills, human skills, and conceptual skills may provide additional knowledge in engineering leadership. Hickman and Akdere (2017, 2018) noted the lack of research in leadership development within the information technology field, thus obtaining real-world perspectives from industry leaders within the information technology field may provide valuable insights into effective leadership skills. Obradović, Montenegro, and Bjelica (2018) considered Katz's three skills model (technical, human, and conceptual skills) when conducting a study with project managers from various industries. The researchers found that conceptual skills were rated as the most important skill but noted that this may not be the case in the other information technology organizations (Obradović et al., 2018).

The importance of the problem stems from the discrepancies in the research findings on skills needed in engineering leadership positions. Hendon, Powell, and Wimmer (2017) suggested that improving engineering leadership may provide new opportunities for an organization. The insights gained from this study may help human resource departments establish a foundation for improving engineering leadership programs and may assist in hiring the right skill set within engineering organizations.

Purpose of the Study

The purpose of this qualitative descriptive study was to explore how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions within the information technology field in the United States. The nature of the phenomenon was the utilization of technical skills, human skills, and conceptual skills in leadership positions by engineering leaders. The target population was all middle and top-level engineering leaders within the information technology field in the United States who had more than two years of leadership experience within the engineering discipline and were connected to the researcher's LinkedIn network, comprised of engineering leaders.

LinkedIn is a professional networking website with a focus on connecting people in the business world. Stokes, Vandyk, Squires, Jacob, and Gifford (2019) noted how LinkedIn is a viable recruiting alternative to quickly reach out to a target population. LinkedIn has members world-wide but only those residing in the United States were included in the study. A description of how engineering leaders utilize technical, human, and conceptual skills may provide additional knowledge in engineering leadership.

Studying the phenomenon of how engineering leaders utilize technical, human, and conceptual skills from a real-world perspective are timely due to the continued dependence on technology. Technology has become a part of everyday life, and organizations are challenged to keep up with the latest technology which requires ongoing improvements in the skills of people involved in the information technology field (Obradović et al., 2018). Kalliamvakou et al. (2017) noted a significant amount of information on the internet regarding engineering leadership skills that are not based on academic research standards. Using empirical research methods to gather insights from engineering leaders may help advance the study of engineering leadership (Kalliamvakou et al., 2017). The researcher in this study provided insights into the utilization of skills in engineering leadership positions, which could help leaders keep up with technology changes and continue the discussion on engineering leadership skills.

Research Questions

The nature of the phenomenon of the study was the utilization of technical skills, human skills, and conceptual skills in leadership positions described by engineering leaders. Katz (2009) described technical skills as the ability to work with things, compared to human skills which focus on working with people, and conceptual skills as the ability to see holistic connections within the organization. In this study, the researcher gained insight into the real-world experiences of engineering leaders through the information gathered in the research questions. The overarching research question was: How do engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions? The following research questions guided the qualitative descriptive study:

RQ1: How do engineering leaders describe the utilization of technical skills in their leadership positions?

RQ2: How do engineering leaders describe the utilization of human skills in their leadership positions?

RQ3: How do engineering leaders describe the utilization of conceptual skills in their leadership positions?

Utilization of technical skills, human skills, and conceptual skills in leadership positions aligns with the theoretical foundation of Katz's (1955) three skills model. In his seminal work, Katz (1955) suggested three skills were valuable for effective leadership which included technical, human, and conceptual skills. Technical skills are needed to accomplish the assigned work, human skills are needed to work effectively with others, and conceptual skills are needed to understand the interconnectivity within the organization to achieve goals (Katz, 1955).

Minh et al. (2017) identified engineering leader's technical skills as up-to-date technical knowledge, with the ability to understand and provide direction to solve technical issues. Matturro et al. (2015) identified human skills such as communication, customer orientation, interpersonal, and teamwork skills as valuable in engineering leadership positions. Conceptual skills, such as problem-solving, driving alignment throughout the organization, and understanding complex situations are important skills for leaders within engineering (Harrison et al., 2018; Kalliamvakou et al., 2017). Obtaining answers to the research questions provided a better understanding of each of these dimensions from the real-world perspectives of engineering leaders.

The research questions were used to explore the utilization of technical skills, human skills, and conceptual skills based on the Katz (1955) model regarding skills needed for effective leadership. The research questions addressed and aligned closely with the problem statement: It was not known how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions.

Advancing Scientific Knowledge and Significance of the Study

The results of the study contributed to the body of knowledge by considering the utilization of technical skills (Kalliamvakou et al., 2017; Katz, 1955; Rottmann et al., 2015), human skills (Katz, 1955; Mayer, Caruso, & Salovey, 2016) and conceptual skills (Harrison et al., 2018; Katz, 1955; Kearns et al., 2015; Medcof, 2017; Northouse, 2018) in engineering leadership positions. The Katz (1955) three skills model was used as the theoretical foundation to guide the research questions. Katz (1955) proposed a model of effective leadership including a combination of technical skills, human skills, and conceptual skills which may be utilized differently within various levels of leadership. This study explored the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions to help expand the engineering leadership theories (Kalliamvakou et al., 2017; Rottmann et al., 2016), and explored the application of Katz's (1955) three skills model of effective leadership within the realm of engineering leadership.

The Katz (1955) three skills model (technical, human, and conceptual skills) was used as the basis to explore participants' descriptions of leadership skills in engineering. The results of the proposed study produced new insights into Katz's (1955) three skills model by gaining what Yin (2016) describes as real-world experiences, from leaders in the engineering discipline. Katz (1955) suggested technical skills were less important at higher levels of leadership, human skills were needed at all levels of leadership, and conceptual skills were increasingly important at in top management positions. Since the seminal article, Katz (2009) made refinements to the three skills model by suggesting managers at all levels need some aspect of the technical, human, and conceptual skills. Researching the utilization of technical, human, and conceptual skills provided validation on Katz's (2009) refinements by considering an application to the descriptions of leaders within engineering.

Gaining an understanding of the utilization of technical, human, and conceptual skills also brought an up-to-date perspective on skills needed in today's engineering leadership positions. Broy (2018) indicated the need for continued education in engineering from both a technical and non-technical perspective to meet the demands of data-driven companies. Based on the ongoing and continuous increase in demand for engineering within all aspects of business (Broy, 2018), understanding the skills needed in engineering leadership may help with the continued education of leaders and upcoming leaders.

Current researchers have conducted studies on engineering leadership from various samples such as junior and senior engineers, human resource representatives, and entrepreneurs (Rottmann et al., 2016) but have not explored the utilization of leadership skills with engineering leaders within the information technology field in the United States. In addition, there are discrepancies in current research on the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions

(Boyatzis et al., 2017; Kalliamvakou et al., 2017; Medcof, 2017; Racine, 2015; Rottmann et al., 2016). Thus, a gap existed, and further research was needed into how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions. The study addressed the discrepancies among current literature and addressed the gap by exploring how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions.

The practical application of this qualitative research included providing new insights, such as skills that upcoming engineering leaders need to be effective in leadership positions. Medcof (2017) acknowledged the lack of leadership development within technology-oriented organizations. Results of this study may improve engineering leadership programs to prepare resources for leadership positions. Human resource departments may be able to use the findings to determine the skills needed for training, hiring, and promoting engineering leaders.

Rationale for Methodology

The researcher used a qualitative methodology in this research study. A qualitative methodology describes ‘how’ or ‘why’ questions of a phenomenon (Yilmaz, 2013). The research questions captured the ‘how’ of the phenomenon: (R1) How do engineering leaders describe the utilization of technical skills in their leadership positions, (R2) How do engineering leaders describe the utilization of human skills in their leadership positions, and (R3) How do engineering leaders describe the utilization of conceptual skills in their leadership positions. The research questions aligned with the problem statement which was also focused on capturing the ‘how’ of the phenomenon: It was not known how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions.

Due to the inductive nature of exploring how engineers utilize technical, human, and conceptual skills in their leadership positions, a qualitative methodology was more relevant than a quantitative methodology. Merriam and Tisdell (2016) noted the value of qualitative research where gaining a perspective from various people can lead to improvements in an organization. A qualitative approach, where the researcher is involved as the instrument, can provide insights when exploring the phenomenon (Merriam & Tisdell, 2016). Using a qualitative methodology provided insight into the perceptions of technical, human, and conceptual skills in engineering leadership from a leader's perspective that can be used to improve leadership within engineering organizations.

Before deciding on a qualitative research methodology, the researcher considered the quantitative methodology. In quantitative research, the focus is on understanding variables and their connections from an objectivist epistemology perspective where the research is based on a statistical measurement of variables based on a deductive approach (Yilmaz, 2013). In other words, the researcher investigates a prediction based on an established theory by utilizing instruments or quantifying variables (Yilmaz, 2013). Greenberger (2015) pointed out the valuable characteristics of using a quantitative methodology to predict, test, and generalize the results to a target population. While quantitative research allows researchers to consider a broad set of findings which may be generalized from the sample, it does not provide detailed insight into the participants' experiences. Yilmaz (2013) noted how responses in quantitative research do not capture the thoughts and experiences in the respondent's own words. A quantitative methodology was not applicable for the study due to the focus on exploring the descriptions of engineering leaders to gain insight on the specific descriptions of the utilization of technical, human, and conceptual skills in their leadership positions.

In contrast to the deductive nature of quantitative research, qualitative research uses an inductive approach to interpret the phenomenon based on how people describe their experiences (Yilmaz, 2013). Instead of using close-ended instruments typically utilized in quantitative research, a qualitative study is based on open-ended responses which allow participants to provide their experiences without any pre-conceived guidelines (Yilmaz, 2013). Thus, based on the descriptive nature of the research questions and the goal of this research study to add to the body of knowledge by gaining insights from engineering leaders, a qualitative methodology was more applicable.

Nature of the Research Design for the Study

A qualitative descriptive design was used in this study. Sandelowski (2000) described qualitative descriptive studies as combining information gleaned from the sample to describe a phenomenon in everyday terms. In other words, using a qualitative descriptive approach may provide contextualized descriptions of the nature of the phenomenon, beyond just stating the facts without understanding the context. Detailed descriptions of a phenomenon can provide perceptions and inclinations from participants' perspective in a natural state (Lambert & Lambert, 2012; Sandelowski, 2000), which the researcher can consolidate into themes based on descriptions from numerous participants.

The study explored descriptions of the utilization of technical skills, human skills, and conceptual skills by engineering leaders to provide additional knowledge in engineering leadership. Colorafi and Evans (2016) pointed out the value of using a qualitative descriptive design to obtain factual responses about how people feel about a topic. Seeking a better understanding of the phenomenon by using a descriptive design provided more descriptive data based on the participants' perceptions of their utilization of skills in engineering leadership positions.

Before selecting a descriptive design, the researcher investigated other qualitative designs such as case study, phenomenology, grounded theory, and narrative. A case study design provides an in-depth analysis of a specific case bound by space or time (Yilmaz, 2013). The bounded system in a case study frames the parameters of the data collection and analysis such as the specific location, process, or timeframe being explored for a particular case (Harrison, Birks, Franklin, & Mills, 2017). The study was not focused on a bounded system because the researcher was exploring the description of the utilization of skills in leadership positions which does not include the interactions of timeframes, processes, and location. Thus, a case study was not applicable to describe how engineering leaders utilize technical skills, human skills, and conceptual skills in their leadership positions.

The grounded theory uses data to create a new theory that is developed over time (Percy, Kostere, & Kostere, 2015). Schmidt (2018) noted that researchers who develop a grounded theory design use numerous approaches and stages for data collection. The result of the data collection is the development of a new theory or model to describe the phenomenon being studied (Schmidt, 2018). A new theory will not be created to address the phenomenon of the study; thus, a grounded theory design was not a good fit.

Yin (2016) noted narrative designs focus on participants' voices to describe a story based on a common life episode. In a narrative design, Schmidt (2018) discussed how the participants tell an interactive story to explain a life event through in-depth interviews which the researcher weaves together to create an overall narrative. The focus of the study was based on exploring descriptions of the utilization of skills, which does not necessitate storytelling, thus a narrative design was not a valid fit for the phenomenon being explored.

A phenomenological design considers the lived experiences with a focus on capturing a unique event (Yin, 2016). In a phenomenological design, the researcher uses multiple data gathering methods to capture the meaning behind the phenomenon (Sauro, 2015). For example, participants may define common lived experiences such as the death of a child and the researcher synthesizes the results to find meaning in the phenomenon (Schmidt, 2018). The focus of the study was not based on looking at the lived experiences of a specific event, so a phenomenological design was not applicable.

The target population was all middle and top-level engineering leaders within the information technology field in the United States who had more than two years of leadership experience within the engineering discipline and were connected to the researcher's LinkedIn network. The unit of observation for the study was engineering leaders who had more than two years of experience leading teams within an engineering organization. The sample consisted of 23 engineering leaders for the Northouse Skills Inventory Survey (2018) and 14 engineering leaders for the interviews, all of whom were in the information technology field in the United States who had more than two years of leadership experience within the engineering discipline and were connected to the researcher’s LinkedIn network. The sources of data collection were a demographic information questionnaire, in-depth semi-structured interviews and Northouse Skills Inventory Survey (2018). Using these data collection methods allowed for the exploration of the perceptions of sample members from a real-world perspective.

A two-step process was used to collect the data from engineering leaders. The first step consisted of contacting middle and top-level engineering leaders in the United States who had more than two years of leadership experience in an information technology field and were connected to the researcher’s LinkedIn network. LinkedIn has members world-wide but only those residing in the United States were included; the professional networking website has over 165 million users across the United States (LinkedIn Corporation, 2019). The researcher sent a recruitment letter to 80 engineering leaders which included a link to SurveyMonkey that contained the consent form, demographic information questionnaire, and the online Northouse Skills Inventory Survey (2018). Once the participants agreed to participate via the consent form, they continued within SurveyMonkey by entering demographic information and completing the online Northouse Skills Inventory Survey (2018) within the SurveyMonkey link, in that unalterable sequence.

The Northouse Skills Inventory Survey (2018) was used to assess the participant’s utilization of technical skills, human skills, and conceptual skills in engineering leadership positions. After each participant completed the Northouse Skills Inventory Survey (2018), the researcher asked the participant if they were willing to do a semi-structured interview to gain further insights into descriptions, elaborations, and explanations, going beyond responses to the initial survey. Kajornboon (2005) noted the benefits of conducting semi-structured interviews in qualitative studies such as probing deeper into questions to get details on the specific phenomenon of skills utilized by engineering leaders. The in-depth semi-structured interview process took place via a virtual meeting site where the researcher recorded the interview and asked follow-up questions to ensure saturation of the description of the phenomenon. Out of the 23 engineering leaders who completed the Northouse Skills Inventory Survey (2018), 14 engineering leaders participated in the semi-structured interviews. Mason (2010) identified saturation as the point where additional data does not lead to new information. The researcher stopped pursuing additional participants for the semi-structured interviews based on the lack of new information emerging in the last two interviews.

Definition of Terms

The phenomenon of the study was the utilization of technical skills, human skills, and conceptual skills in leadership positions by engineering leaders. The theoretical foundation stemmed from Katz's (1955) three skills model of leadership which was applied to the engineering discipline within the information technology field. The following terms provided a foundation for the concepts used throughout the study:

Conceptual skills. In his seminal article, Katz (1955) provided a description of conceptual skills which involves the ability to see the organization as a whole, recognize how different areas of the organization relate to each other, and how the organization relates to the industry and society to advance the best interests of the organization.

Engineering leadership. Rottmann et al. (2015) associated the term engineering leadership with individuals who were in positions of responsibility such as project leaders, team leaders, and process leaders.

Human skills. The term human skills refer to a leader's ability to work with others (Katz, 1955). Katz (1955) identified human skills as the way individuals perceive and behave with others, which was also coined emotional intelligence by Salovey and Mayer (1990) when they suggested that people have the ability to understand the behaviors of others. For the purpose of this study, the terms human skills and soft skills will be used interchangeably.

Information technology field. The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) created a joint committee to define systems and software engineering vocabulary (IEEE, 2017). The IEEE (2017, p. 223) defined information technology as "resources required to acquire, process, store and disseminate information".

Technical skills. Katz (1955) described technical skills as the proficiency in a specific task which requires specialized knowledge within a specific discipline. Within information technology, Kappelman, Jones, Johnson, McLean, and Boonme (2016) identified components of technical skills such as programming languages and hardware/software analysis.

Assumptions, Limitations, Delimitations

Assumptions. Ellis and Levy (2010) identified the function of assumptions in research is to explain things that are accepted as true even if there is no concrete proof this is the case. The researcher identified the following assumptions for the study:

1. It was assumed that the participants involved in the study were credible and knowledgeable in the subject of engineering leadership skills. The sample included participants who have been in leadership roles for more than two years within the engineering discipline.

2. It was assumed that the participants provided honest responses to the interview and Northouse Skills Inventory Survey (2018). The researcher informed the

participants that the results of the data gathering will be kept confidential and the names of participants will not be included in the study.

Limitations. Limitations exist within studies because the researcher does not have control over everything, thus the results of the study may not have complete certainty (Ellis & Levy, 2010). The following limitations were present in this study:

1. The researcher conducted the Northouse Skills Inventory Surveys (2018) and interviews with engineering leaders who have numerous responsibilities in their daily jobs. Boyatzis et al. (2017) noted a limitation in the study of engineers due to time-sensitive demands within organizations. To address this potential limitation, the researcher proactively set expectations on the time needed from the sample to participate in both the survey and interviews.

2. The researcher had prior connections with some of the participants in the study based on the fact that the researcher was in the information technology field. Due to the connection with the participants, the researcher refrained from potential bias and obtained objectivity when analyzing the results of the study. To reduce bias, the researcher removed demographic information and participant names prior to starting the coding process. Thus, the coding was done without any knowledge of who provided the data. Based on prior connections with the researcher, the participants may not feel comfortable providing responses to the interview questions. The researcher reiterated the autonomy and confidentiality of the study.

Delimitations. Delimitations are the boundaries set by the researcher for the study (Ellis & Levy, 2010). The following delimitations are part of the study:

1. The study included purposive sampling with 23 engineering leaders for the Northouse Skills Inventory Survey (2018) and 14 engineering leaders for the interviews, all of whom were within the information technology field in the United States who had more than two years of leadership experience within the engineering discipline. LinkedIn has members world-wide but only those residing in the United States and had were connected to the researcher's LinkedIn account were included in the study. Yilmaz (2013) indicated how purposive sampling is key in qualitative designs because the researcher is studying a small sample of participants to gain a detailed understanding of the phenomenon. The nature of the qualitative descriptive design involved a small sample size to explore how engineering leaders described the utilization of technical, human, and conceptual skills; thus, a large sample size was prohibitive to complete an in-depth study of the phenomenon.

2. The researcher delimited the timeframe of the Northouse Skills Inventory Survey (2018) and in-depth interviews with engineering leaders to a two-month period to

complete the study in a timely fashion and not turn the study into a longitudinal study.

3. A qualitative descriptive design for the study was selected to explore perceptions of engineering leaders in a natural state. Lambert and Lambert (2012) noted the value of using a descriptive design to gain a straightforward description of the phenomenon in its natural state.

Summary and Organization of the Remainder of the Study

The field of information technology continues to expand with the increased use of computers in business and everyday life (Beckhusen, 2016). As the use of technology increases, the need for engineering roles increases, as does the need for engineering leaders. Kalliamvakou et al. (2017) acknowledged the significant number of theories on management but noted the value of considering leadership theories by understanding how the theories are utilized in the everyday lives of technology leaders. While there are existing studies on leadership, there was still a need to consider leadership within the engineering discipline (Kalliamvakou et al., 2017). Capretz and Ahmed (2018) noted the importance of additional skills, beyond technical skills, that are needed in engineering leadership. Transitioning from an individual contributor role to a management role may be a struggle if the new leader is not equipped with skills needed to manage teams (Capretz & Ahmed, 2018).

This qualitative descriptive study used the theoretical foundation of Katz's (1955) three skills model to address the problem statement: It was not known how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions. Descriptive designs can provide a summary of events in everyday terms (Sandelowski, 2000). The descriptive design allowed the participants to describe the utilization of technical, human, and conceptual skills in everyday language. Data was gathered through a Northouse Skills Inventory Survey (2018) and in-depth interview questions from a sample of 23 engineering leaders for the surveys and 14 engineering leaders for the interviews, all of whom were in the information technology in the United States, had more than two years of leadership experience within the engineering discipline, and were connected to the researcher's LinkedIn network. LinkedIn has members world-wide but only those residing in the United States and connected to the researcher's LinkedIn account were included in the study. The purpose of this qualitative descriptive study was to explore how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions within the information technology field in the United States. The purpose of the study determined the following research questions: (R1) How do engineering leaders utilize technical skills in their leadership positions, (R2) How do engineering leaders utilize human skills in their leadership positions, (R3) How do engineering leaders utilize conceptual skills in their leadership positions. The goal of the study was to expand the body of knowledge on engineering leadership skills in relation to previous studies on engineering leadership (Kalliamvakou et al., 2017; Rottmann et al., 2016) and further exploration of Katz's (1955) three skills model in relation to engineering leadership. The practical application of the study may result in information that can improve engineering leadership training programs to prepare future leaders.

Chapter 2 includes a description of the theoretical foundation of the study and provides an in-depth literature review on current research with the themes of engineering, leadership, and skills for effective leadership. Chapter 3 is used to document how the study was conducted by including the research methodology, design, population, and sample selection. Chapter 4 was written to present how the data were collected and analyzed to culminate in the results of the study. Chapter 5 will provide a summary of the study and how the study contributed to the body of knowledge.

Chapter 2: Literature Review

Introduction to the Chapter and Background to the Problem

This chapter includes a detailed discussion of the theoretical foundation and existing literature regarding effective leadership skills within the information technology field. Leaders in the technical world of engineering must keep up with fast-changing technologies, understand the conceptual aspects of the business, and communicate effectively with others in the organization (Kalliamvakou et al., 2017; Medcof, 2017). The evolving world of technology will continue to put pressure on leaders within information technology to modify their roles and skillsets (Williams, 2016).

The skillset needed for an engineering role compared to an engineering leader role have different characteristics. Perry et al. (2017) noted how engineers are taught technical principles based on their discipline, compared to engineering leaders who need to have additional skills such as people skills and strategic thinking. AbuJbara and Worley (2018) noted the value of conceptual skills, interpersonal skills, and leadership skills to achieve professional excellence and stay competitive in the business world. Thus, it is valuable to consider how engineering leaders utilize technical, human, and conceptual skills in leadership roles to improve engineering leadership.

Within this chapter, the researcher will discuss the theoretical foundation for the study based on Katz's (1955) three skills model and provide a background on the literature centered around engineering, leadership, and skills for effective engineering leadership. The chapter will consist of the following sections: Introduction to the Chapter, Background to the Problem, Identification of the Gap, Theoretical Foundation, Review of Literature, Methodology and Instrumentation/Data Sources/Research Materials, and

Summary. The summary concludes the literature review with a transition to the methodology section.

Each section of the literature review will have subsections to provide detailed information on the current literature and the need for future studies. For example, in the first section of the engineering topic, background will be provided on the history of information technology as well as future directions. In the second subsection of engineering, the researcher will discuss the current literature on engineering leadership skills. The last subsections of the engineering topic will examine engineering leadership and effective engineering leadership, including discrepancies between studies and the need for future research.

The leadership section of the literature review will include the following subsections: background on the leadership approaches, effective leadership, and leadership development. Considering the various perspectives of researchers on leadership competencies and development can set the stage for future research on effective engineering leadership. Northouse (2018) suggested a skill-based leadership model may be useful for developing effective leaders. Medcof (2017) pointed out the importance of leadership development, especially within the information technology management field. Hence, it is valuable to understand how leadership literature relates to effective engineering leadership.

The section on skills for effective engineering leadership will be based on the theoretical foundation of Katz's (1955) three skills model and will include current research within the context of technical skills, human skills, and conceptual skills. There are discrepancies within the literature on the importance of technical skills in engineering leadership positions (Kalliamvakou et al., 2017; Rottmann et al., 2016) and minor consideration for conceptual skills in engineering leadership (Medcof, 2017). Research on human skills is plentiful, including literature on emotional intelligence, social intelligence, and soft skills (Caruso, Bhalerao, & Karve, 2016; Goleman, 2000; Lopes, 2016; Mayer et al., 2016; Salovey & Mayer, 1990) yet researchers continue to identify a need for future research, especially within engineering leadership (Boyatzis et al., 2017; Kalliamvakou et al., 2017; Medcof, 2017; Racine, 2015; Rottmann et al., 2016).

The existing literature was surveyed by using key search terms and Grand Canyon University library search engines. The following search engines within the Grand Canyon University library were used: *EBSCO, Emerald Management, IEEE Xplore, LearnTech Lib Digital Library, Mental Measurements Yearbook, ProQuest, Sage Research Methods, Sage Premier, Taylor and Francis, and Google Scholar.* The keywords used to find scholarly articles included the following terms: *Engineering, Information Technology, Leadership, Engineering Leadership, Effective Leadership, Leadership Development, Leadership Skills, Soft Skills, Emotional Intelligence, Emotional-Social Intelligence, Conceptual Skills, Human Skills, Technical Skills.* In addition to the GCU library, the researcher utilized government websites such as the *Bureau of Labor Statistics, National Academy of Engineering,* and the *Accreditation Board for Engineering and Technology* to understand current trends within the information technology field.

Background to the problem. To gain an understanding of the phenomenon regarding the utilization of technical skills, human skills, and conceptual skills in leadership positions by engineering leaders, it is valuable to consider how the problem has evolved historically. Researchers have studied managerial skills throughout the years, but according to Northouse (2018), Katz stands out as providing seminal work in the area of skills for effective leadership. Katz (1955) created a three skills model of effective administration which included technical, human, and conceptual skills. The premise of Katz's three skills model was based on the notion that leaders can develop skills for effective leadership and leaders display the skills through effective job performance (Katz, 1955). Katz (1955, p. 36) defined the concept of skills "as an ability to translate knowledge into action" which can lead to understanding engineering leadership by analyzing the utilization of technical skills, human skills, and conceptual skills.

Following Katz's seminal article on skills needed for effective administration, Mann (1965) conducted several studies that provided empirical support for Katz's three skills model and showed the importance of technical, human, and conceptual skills at the managerial level. More recently, Katz (2009) provided refinements to the seminal article, such as providing additional insights into human skills, conceptual skills, and technical skills which researchers can validate as part of future research. The initial claims by Katz are still influential in current research (Northouse, 2018) and management research within the technology industry (Medcof, 2017).

Understanding the leadership skills needed within the information technology field is an ongoing concern among researchers (Hickman & Akdere, 2018). The Bureau of Labor Statistics (2019) is projecting a 12% growth in computer and information systems management positions between 2016 and 2026, which is faster than the 7% projection for growth in other management occupations over the same timeframe. As the need for information technology managers continues to grow, the need to develop leaders becomes important to fill the pipeline for engineering leadership positions. Beckhusen

(2016) noted that 20% of the information systems managers were over 54 years old, which indicates a future need to develop new leaders. The development of leaders within engineering is vital to the survival of organizations, yet leadership development within the information technology field has not received much attention by researchers (Hickman & Akdere, 2018).

Based on the background of the problem and the ongoing need for research on engineering leadership, research is needed into how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions (Boyatzis et al., 2017; Kalliamvakou et al., 2017; Medcof, 2017; Racine, 2015; Rottmann et al., 2016). Gaining a better understanding of how engineering leaders utilize skills may add to the body of knowledge by providing real-world perspectives which organizations can use to develop future leaders.

Identification of the Gap

Information technology has become an integral part of organizations to support the fast-changing global business world. There has been a continuous increase in information technology-intensive jobs due to ongoing advances in technology (Gallipoli & Makridis, 2018) which has led to an increased need for a pipeline of technology leaders (Hickman & Akdere, 2018). Technology leaders play a key role in managing both engineering teams and working with business leaders in a global economy. AbuJbara and Worley (2018) noted how leaders need human skills and conceptual skills, in addition to technical skills, to support business environments due to heavy reliance on technology. Although it is foundational for engineers to have technical capabilities, engineering leaders need additional skills to work with teams and solve complex problems (Boyatzis et al., 2017; Kalliamvakou et al., 2017).

Capretz and Ahmed (2018) discovered that people moving into engineering leadership positions struggled with the human aspects of the role. Perry et al. (2017) pointed out "…when an organization's best engineer is promoted to a leadership role, the organization loses the best engineer and gains the worst leader." (p. 3). The technical aspects of engineering may allow engineers to stand out among their peers, but additional skills may be needed when moving from an individual contributor role to a leadership position (Capretz & Ahmed, 2018). Thus, a better understanding of how engineering leaders utilize their skills may help prepare upcoming leaders to be more successful in engineering leadership positions.

This research study was conducted to address discrepancies and lack of research regarding skills needed for effective engineering leadership. Rottmann et al. (2015) created a grounded theory of engineering leadership based on a qualitative study with engineers to identify key competencies in engineering leadership such as technical mastery, collaborative optimization, and organizational innovation. The work by Rottmann et al. (2016) extended research in engineering leadership, with a focus on engineers from various disciplines, but the sample in the study did not include engineering leaders in the information technology field in the United States.

A year later, Kalliamvakou et al. (2017) studied engineering leadership and discovered unexpected results in the perception of technical skills needed for information technology leadership, which contradicted the results found by Rottmann et al. (2016). Also, Kalliamvakou et al. (2017) found that respondents, who consisted of engineers and managers, ranked technical skills lower than human skills and suggested expanding research into other engineering organizations to validate the results. Boyatzis et al. (2017) noted the significance of human skills, such as those related to emotional intelligence, regarding engineering effectiveness but did not consider the perspectives of engineering leaders.

Researchers to this point have considered engineering leadership skills through the lens of engineers, human resources representatives, interns, entrepreneurs, and politicians (Rottmann et al., 2016) and have considered the human and technical aspects of engineering leadership (Boyatzis et al., 2017; Kalliamvakou et al., 2017; Racine, 2015; Rottmann et al., 2016). A limited number of studies have considered the utilization of conceptual skills in engineering leadership (Capretz & Ahmed, 2018; Medcof, 2017). However, based on findings from the existing research, a problem has emerged, centered around the need to better understand the real-world experiences of engineering leaders' utilization of skills in leadership positions. It is not known how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions.

Although some of the existing studies resulted in recommendations for competencies needed in leadership engineering positions, the samples consisted of engineers who were not in leadership roles; expanding the research to include engineers in leadership roles is a necessary next step (Boyatzis et al., 2017; Rottmann et al., 2016). To address this gap in the existing literature, research was needed on how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions (Boyatzis et al., 2017; Kalliamvakou et al., 2017; Medcof, 2017; Racine, 2015; Rottmann et al., 2016).

Theoretical Foundation

The theoretical foundation for the study was based on Katz's (1955) three skills model of an effective administrator. Katz's (1955) three skills model provided the foundation for exploring the utilization of technical skills, human skills, and conceptual skills in leadership positions by engineering leaders. This researcher utilized Katz's (1955) three skills model to guide the research questions of the study: (R1) How do engineering leaders utilize technical skills in their leadership positions, (R2) How do engineering leaders utilize human skills in their leadership positions, and (R3) How do engineering leaders utilize conceptual skills in their leadership positions. A qualitative descriptive methodology and research design were used to address the research questions, with Northouse Skills Inventory Survey (2018) and in-depth interviews intended to obtain descriptions of the utilization of technical, human, and conceptual skills from a real-world perspective from engineering leaders.

Katz (1955) wrote a seminal article that focused on the type of skills leaders need to perform effectively. Before Katz's article, researchers focused on innate traits and characteristics that distinguished a leader, so Katz set out to challenge the concept of what makes an effective leader (Katz, 1955). Based on field observations and study within the research field of administration, Katz postulated that people could develop skills to be effective leaders and suggested a three skills model which included technical skills, human skills, and conceptual skills. Thus, instead of only considering innate leadership traits when selecting, hiring, or promoting people into leadership positions, the development of skills should be a consideration for leadership positions (Katz, 1955).

Within the seminal article, Katz (1955) acknowledged how the three skills (technical, human, and conceptual) of an effective administrator are interrelated, yet also stand on their own merit, so it is valuable to understand the background of each skill individually and holistically. Katz (1955) described technical skills as having proficiency and specialized knowledge within a specific discipline. The development of technical skills has been the focus within organizations throughout the years due to the concrete nature of training individuals and following up with on-the-job experience (Katz, 1955). As part of his analysis, Katz (1955) suggested that technical skills are more prominent in lower-level leadership positions and become less necessary in top management positions.

In 2009, Katz updated his thoughts on technical skills by suggesting leaders in higher-level management positions need to have enough technical knowledge, such as industry background, to make good business decisions. Hence, the first research question, which explores how engineering leaders describe the utilization of technical skills in their leadership positions, considered the technical skills aspects of Katz's (1955, 2009) skills-based model.

Leaders within organizations may use technical skills to work on processes or physical objects, but also need human skills that focus on working with people (Katz, 1955). According to Katz (1955), leaders demonstrate human skills through self-reflection, such as paying attention to personal reactions and being aware of people's behavior. In other words, human skills are the ability to work effectively with others and are an important skill at every level of management (Katz, 1955). Katz (1955) indicated the focus on developing human skills includes improvements in areas such as communication skills, empathy, self-awareness, and awareness of others. Organizations may consider various ways to improve human skills such as formal training, coaching, role-playing, self-assessments, and analyzing case studies with real-world situations (Katz, 1955).

Similar to technical skills, Katz (1955) suggested that leaders in lower levels of management may have higher utilization of human skills due to the number of direct contacts with subordinates, but in contrast to technical skills, human skills continue to be valuable at all levels of management. Katz (2009) further refined his thinking on human skills by clarifying the different levels of human skills such as intragroup skills at lower levels of management and intergroup skills which may be more important at higher levels of management. Thus, the second research question to explore how engineering leaders describe the utilization of human skills may bring new insights into the need to develop human skills within organizations.

In addition to technical and human skills, Katz (1955) specified leaders, especially in higher-level management positions, need conceptual skills. Conceptual skills consist of leaders being able to see the organization as a whole by understanding the interconnectivity between the subsystems, setting a vision, defining objectives, and making decisions that are in the best interest of stakeholders (Katz, 1955). Similar to the development of human skills, Katz (1955) suggested that leaders can develop conceptual skills through individualized coaching and formal classrooms, but also included ideas such as trading jobs and developing critical thinking skills.

Katz (2009) altered his initial thoughts on the utilization of conceptual skills and suggested that leaders may need conceptual skills at all levels of leadership within the organization. The third research question will add to the ongoing discussion of conceptual skills in leadership positions by exploring how engineering leaders describe the utilization of conceptual skills in their leadership positions.

Katz (1955) discussed each skill (technical, human, and conceptual) separately, but noted the importance of developing all three skills to be an effective leader. The research questions in the study explored how engineering leaders describe the utilization technical skills, human skills, and conceptual skills in their leadership positions to improve engineering leadership.

Review of the Literature

This literature review was structured to provide an overview and analysis of current research related to effective leadership skills and engineering as a basis for further exploration of the phenomenon regarding the utilization of technical skills, human skills, and conceptual skills in leadership positions by engineering leaders. Recent researchers have stressed the need for engineering managers to develop leadership skills to support the teams they lead and indicated a need for further empirical research to guide optimal use of engineering leadership skills (Kalliamvakou et al., 2017). Researchers have continued studying engineering leadership; the researchers suggested future studies be focused on real-world experiences of engineering leaders to gain insights into the utilization of skills in engineering leadership positions (Hickman & Akdere, 2018; Kalliamvakou et al., 2017; Rottmann et al., 2016).

There were also contradictions between studies, such as the findings by Kalliamvakou et al. (2017) regarding the lack of importance of technical skills needed for information technology leadership, which contradicts the results found by Rottmann et al. (2016) who identified technical competence as an important skill in engineering leadership positions. While current research studies on engineering leadership have considered technical and human skills, there was a lack of research on the utilization of conceptual skills among engineering leaders (Medcof, 2017). Capretz and Ahmed (2018) described the challenges faced by new engineering managers which included the level of technical skill needed in leadership positions as well as learning how to shift to conceptual (e.g. big picture) thinking and suggested the need to continue research to help prepare leaders within engineering.

Information technology background and future direction. As part of the foundation of the existing literature, understanding the background of information technology shows the importance of engineering throughout history. As the need for information technology continues to grow within organizations, there is an increased demand for engineering leaders (Cetindamar et al., 2016). Considering the background of information technology and the future direction of current research provided insights into the engineering discipline and provided a starting point for the study of engineering leadership skills.

The management and utilization of information has continued to accelerate throughout the years (Beckhusen, 2016). Cortada (2017) noted various stages of advancement in information handling with the industrial revolution, followed by the arrival of computers, and then the onset of the Internet. With this acceleration of information, the area of information technology has continued to grow over the last century and continues to accelerate. Silva and Di Serio (2016) discussed the acceleration of information in waves of innovation throughout history, starting with the industrial revolution and continuing through the rise of information technology. For instance, the Industrial Revolution started the advancement of technology through industrialization, followed by the age of steam, electricity, mass production, and the introduction of the internet (Silva & Di Serio, 2016). With the continued advancement in technology, Silva and Di Serio (2016) suggested the next wave of innovation may be focused on sustainability to improve competitive advantage. Perri et al. (2019) also described the rapid growth in information technology which has continued to challenge the skill sets of engineering leaders. The continued growth of the information technology field lends itself toward continuing research with a focus on engineering leadership.

The demand for information technology continues to be a significant trend in the business world. Kappelman et al. (2018) indicated spending on information technology as a percent of revenue was up 14.7% in the past 24 months, with a focus of the spending going toward people. Based on the increase in spending within information technology, there are growing concerns on the skills development within the field (Kappelman et al., 2016). The advancements in information technology continue to fuel the competition between organizations and are necessary for survival in the hypercompetitive business world (Wang et al., 2016).

Cetindamar et al. (2016) acknowledged the increased dependency on information technology and suggested leaders may need to have the expertise and additional skills to be effective in technology positions. Similarly, Kappelman et al. (2016) emphasized the need for engineering leaders to have technical skills as well as additional management skills to be successful in meeting organizational goals. Paul et al. (2018) noted the importance of engineering leaders having non-technical attributes to navigate through business environments. When considering the future direction of engineering, it is important to consider the development of skills within engineering leadership positions (Capretz & Ahmed, 2018).

Engineering leadership skills. Research has shown that engineers who transition into leadership roles struggle to grasp management skills (Capretz & Ahmed, 2018; Kappelman et al., 2016; Perry et al., 2017). There is an ongoing debate in the engineering literature regarding the utilization of technical skills in general engineering leadership positions, but less emphasis specific to leaders in the engineering discipline. Some researchers have acknowledged engineering leaders have a foundation of technical skills but disagree on the level of technical skills needed in engineering leadership positions (Kalliamvakou et al., 2017; Kappelman et al., 2016; Minh et al., 2017). For example, Kappelman et al. (2016) discussed the need for engineers to continue developing technical skills in the progression toward leadership roles. Kalliamvakou et al. (2017) considered technical skills from an engineering leadership perspective and defined being technical as "knowledgeable about the system and technologies the engineer is working with, understanding the complexity of problems and solutions, and have input for design dilemmas." (p. 7).

Identifying the skills needed in technical leadership roles can be challenging due to the constant evolution of technology which drives change in organizations (Kappelman et al., 2016). Minh et al. (2017) also discussed the level of technical skills needed in engineering leadership positions, but in contrast to Kappelman et al. (2016), indicated the importance of detailed technical knowledge. Minh et al. (2017) noted the importance of technical skills in leadership positions within technology-intensive industries. Future researchers can gain a better understanding of the use of technical skills by conducting research on engineering leadership within various industries (Schell & Kauffmann, 2016). There is a need to continue exploring the utilization of technical skills in engineering leadership within the information technology field to keep up with the changing demands based on advances in technology.

Strong technical skills may set engineers apart from their peers, but engineers also need soft skills, especially as they progress into leadership positions (Capretz & Ahmed, 2018). Researchers have attempted to define soft skills by using various descriptions such as people skills, non-technical skills, human skills, and the ability to work with people (Farr et al., 1997; Katz, 1955; Matteson et al., 2016; Northouse, 2018). Farr et al. (1997) postulated engineers may be successful due to strong technical skills, but also need to develop non-technical skills to be successful in a career path toward leadership.

Since the seminal work by Farr et al. (1997), researchers have continued studies on leadership skills. Within the realm of non-technical skills, researchers have studied emotional intelligence in relation to engineering leadership. Elegbe (2015) conducted a qualitative study with engineering graduates and managers in industries such as telecommunications and found engineering managers deemed emotional intelligence as more important than technical competencies in leadership positions.

In another study published in the same year, Matturro et al. (2015) interviewed team leaders and team members in 11 software development companies regarding the utilization of soft skills. The researchers discovered that software team leaders utilized different soft skills than team members (Matturro et al., 2015). For example, the skills associated with software engineering team leaders included leadership, communication, customer orientation, interpersonal, and teamwork skills whereas the skills associated with software engineering team members included problem-solving, teamwork, responsibility, commitment, eagerness to learn, and motivation (Matturro et al., 2015). Based on the results from the study, Matturro et al. (2015) suggested further work be undertaken with companies to continue the discussion about the utilization of soft skills within the engineering discipline.

While numerous researchers have considered the utilization of technical skills and non-technical skills in relation to engineering leadership, there is less research on the utilization of conceptual skills within engineering leadership (Medcof, 2017). Katz (1955) initially described conceptual skills as the ability for leaders to work with concepts such as problem-solving and pointed out that higher-level leadership positions may be more likely to utilize conceptual skills. A small number of researchers have considered conceptual skills when studying leadership and even less have focused on the utilization of conceptual skills with engineering leadership positions.

For example, Kearns et al. (2015) explored how leaders within the non-profit industry utilized leadership skills and found leaders used conceptual skills less than human and technical skills. The findings by Kearns et al. (2015) differed regarding the utilization of conceptual skills as indicated by Katz (1955). Kearns et al. (2015) interviewed 20 nonprofit chief executive officers regarding the skills utilized in daily leadership positions. The researchers found interpersonal skills were mentioned by 51 percent of the respondents, compared to 36 percent mentioning technical skills, and 13 percent mentioning utilization of conceptual skills (Kearns et al., 2015). The results showed the leaders utilized technical skills and human skills more often than conceptual skills, which is in contrast to Katz's (1955) assertion that conceptual skills are most important in top leadership positions.

Medcof (2017) reviewed technology management literature to gain a better perspective on how leaders use skills such as conceptual skills at different levels of leadership and found varying degrees of literature. For instance, the research indicated that conceptual skills were present at the lower levels of management, such as leaders of small groups, but research was lacking in the utilization of conceptual skills at the middle and upper management levels (Medcof, 2017). In a mixed study, Rottmann et al. (2016) identified problem-solving as one of the skills used by engineering leaders, which falls into the conceptual skills area defined by Katz (1955). Rottmann et al. (2016) suggested additional research with leaders across career trajectories in engineering to gain more knowledge on the utilization of skills.

Researchers in engineering look at leadership through the lens of the engineering field. Farr et al. (1997) started the discussion of engineering leadership development regarding engineering managers and provided the initial thoughts on what skills engineering leaders need to be successful. Farr et al. (1997) defined leadership as "the process of influencing an organized group toward accomplishing its goals." (p. 38). As engineers progress from an individual contributor to a leadership role, the focus of skills changes from technical skills to human skills to leadership skills (Farr et al., 1997). Farr et al. (1997) agreed with the seminal management skills suggested by Katz (1955) on the need for technical and human skills in leadership positions. Katz (1955) and Farr et al. (1997) agreed that technical skills and human skills were important for leaders in lower-level management positions, but Farr et al. (1997) did not discuss the conceptual skills proposed by Katz (1955).

While there were some areas of agreement between Farr et al. (1997) and Katz (1955), there were also differences. For example, Katz (1955) asserted the third skill needed for effective management was conceptual skill wherein the leader sees connections within the whole organization and makes decisions in the best interest of stakeholders. Farr et al. (1997) suggested the third skill needed by engineering managers was leadership skills based on nine qualities: big thinker, high ethics, master of change, risk-taker, having a mission, making hard decisions, using power wisely, team building, and effective communication. Since the seminal articles by Katz (1955) and Farr et al. (1997), many follow-up studies have considered the aspects of engineering leadership. While Farr et al. (1997) were one of the first researchers to consider leadership within engineering, future studies have provided a more methodical approach to research on engineering leadership (Rottmann et al., 2016).

Qualitative grounded theory studies and mixed-method studies examined the components of engineering leadership which led to similar findings on the need for technical skills (Perry et al., 2017; Racine, 2015; Rottmann et al., 2015). Similar to the findings of Farr et al. (1997), the studies by Perry et al. (2017), Racine (2015), and Rottmann et al. (2015) had a common thread regarding the concept of technical competency in engineering leadership and agreed that new engineering leaders needed additional leadership training.

Perry et al. (2017) utilized a mixed-method approach to capture both quantitative and qualitative data from different roles within an engineering research center and acknowledged the need for technical skills but proposed a model to facilitate the development of engineering leaders by combining technical skills and leadership skills. Racine (2015) conducted a qualitative study with managers from various engineering disciplines and concluded that engineers moving into leadership roles had the technical competency but lacked training in other aspects of leadership. Racine (2015) acknowledged the importance of technical competence as a baseline for engineers moving into leadership roles but suggested new engineering leaders need additional skills to be an effective leader in engineering. Rottmann et al. (2015) echoed this thought by identifying technical mastery as a key engineering skill.

By combining the conclusions of prior researchers, a common theme emerged to show the value of linking technical competencies and engineering leadership competencies to meet organizational goals (Perry et al., 2017; Racine, 2015; Rottmann et al., 2015). In contrast, Kalliamvakou et al. (2017) found unexpected results in a qualitative study which suggested people management skills were more important than technical skills in engineering leaders. While some level of technical knowledge was necessary to understand and guide the team, interviews with managers and engineers found that a manager with a high level of technical knowledge may be a detriment to the team and suggested further research to validate these results (Kalliamvakou et al., 2017). Based on the discrepancies among researchers regarding the need for technical skills in engineering (Kalliamvakou et al., 2017; Perry et al., 2017; Racine, 2015; Rottmann et al., 2015), further research may provide additional insights to add to the body of knowledge in engineering leadership.

Effective engineering leadership. There are significant similarities and differences in the literature regarding the type of leadership skills needed for effective engineering leadership. Perry et al. (2017) and Racine (2015) agreed on the need for technical competencies as well as big-picture thinking but provided different suggestions on leadership skills to meet organizational goals. In addition to technical competencies, Racine (2015) suggested the concept of group and organization vectors where engineering leaders focus on meeting the needs of followers through actions such as communication, interaction, and coordination through all levels of the organization.

If new engineering leaders only relied on technical skills without leadership skills, they may not be successful in leadership positions (Racine, 2015). Perry et al. (2017) considered the big-picture view, which included the ideas of building bridges and coordinating across networks to be an effective engineering leader but added additional criteria to developing engineering leaders. Boundary breaking collaboration and orchestrated commercialization were two addition concepts identified as necessary for engineering leaders (Perry et al., 2017). The concept of boundary-breaking collaboration included the ability to share information across the organization and industry whereas the idea of orchestrated commercialization promoted the ability to take a technical idea to a commercial pipeline (Perry et al., 2017). Perry et al. (2017) and Racine (2015) agreed on the need for technical competencies and big picture thinking as part of engineering leadership, yet other researchers have taken different paths in research on engineering leadership.

Researchers within the education arena have analyzed engineering leadership based on a combination of leadership skills and engineering competencies. Rottmann et al. (2015) created a grounded leadership theory within the engineering leadership area which included three orientations: technical mastery, collaborative optimization, and organizational innovation. Technical mastery combines the concepts of a coaching style leadership with technical abilities where the leader provides mentoring to engineers and establishes technical respect throughout the organization (Rottmann et al., 2015). The second orientation, collaborative optimization, consists of facilitation leadership skills to bridge gaps within the organization and leverage team member's strengths (Rottmann et al., 2015). The third orientation, organization innovation, is like visionary leadership but also incorporates operationalization of the vision (Rottmann et al., 2015). The ability of an engineering leader to take an idea from conception to a viable product or service may increase the engineer's leadership credibility (Rottmann et al., 2015).

In 2016, Rottmann et al. extended the initial leadership study (Rottmann et al., 2015) by exploring engineering leadership through the eyes of various roles such as engineers, human resources professionals, entrepreneurs, politicians, and interns which provided a broader view into engineering leadership. The researchers modified the elements from the original study (Rottmann et al., 2015) to include mastery of engineering competencies, organizational awareness, innovation, public service, and creation of a learning environment (Rottmann et al., 2016). Rottmann et al. (2018) continued the discussion on engineering leadership through the analysis of engineering literature and provided recommendations for future research such as exploring perceptions of engineering leaders within various industry contexts. Research to explore how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions may add to the body of knowledge in engineering leadership.

Leadership approaches. The evolution of leadership has taken many turns throughout history and several leadership approaches have emerged in the past 30 years. Northouse (2018) described the differences between a trait approach, a behavior approach, and a skilled approach in leadership. A trait approach emphasizes personality characteristics, compared to a behavior approach which emphasizes the behaviors of a leader, and a skilled approach which emphasizes capabilities (Northouse, 2018). Some of the major trait leadership characteristics include intelligence, self-confidence, determination, integrity, and sociability (Northouse, 2018). The behavioral approach focuses on behavior patterns and how the patterns impact leadership, such as transformational, charismatic, or leader-member exchange (Mumford, Zaccaro, Harding, Jacobs, & Fleishman, 2000). The skilled approach is based on seminal work by Katz (1955) and a follow-up study by Mumford et al. (2000) which considered leadership based on capabilities such as technical, human, and conceptual skills.

The theoretical foundation of the study was based on Katz's (1955) three skills model. Katz's (1955) model falls under the skilled approach in leadership (Northouse, 2018). Understanding existing research on leadership approaches, such as skill-based leadership, provides a connection between the theoretical foundation of Katz's (1955) three skills model and Northouse's (2018) skill-based leadership approach.

Researchers continue to utilize the idea of a skilled approach within studies to understand the development of skills to improve leadership capabilities (Harrison et al., 2018; Hickman & Akdere, 2018; Kearns et al., 2015; Nix & Bigham, 2015; Uhr, 2017). Uhr (2017) noted the value of learning technical skills, human skills, and conceptual skills to improve leadership capabilities and suggested researchers conduct additional descriptive studies to continue exploring leadership skills. Kearns et al. (2015) conducted a qualitative study by interviewing leaders and postulated that people can develop leadership capabilities by improving skills through both education and real-world experiences. There are numerous leadership roles within engineering, such as organizations who have dual career paths which include a management path and an individual contributor technical path (Hickman & Akdere, 2018). Thus, effective leadership is key in both the management path and individual technical path due to interactions with stakeholders (Hickman & Akdere, 2018).

Nix and Bigham (2015) conducted a case study using the foundation of Katz's (1955) three skills model and Northouse's (2018) skill-based leadership approach to study skills needed for effective leadership within the education field. Nix and Bigham (2015) identified skills such as experience within the school district, ability to balance time and flexibility, having a positive attitude, problem-solving abilities, and a willingness to do hard things as key skills needed for effective leadership within the school district. The researchers concluded searching for leaders with a combination of technical, human, and conceptual skills may be beneficial in selecting the right candidate (Nix & Bigham, 2015).

Harrison et al. (2018) conducted a qualitative study based on a skill-based approach using the three skills models suggested by Katz (1955) and Mumford et al. (2000) to explore leadership from an entrepreneurial perspective. The researchers demonstrated the value of the Katz's (1955) three skills model and identified specific types of technical, human, and conceptual skills leaders may utilize in leadership positions (Harrison et al., 2018). Northouse (2018) indicated organizations have not focused on a skill-based approach when creating training programs for leadership positions. Gaining a better understanding of how engineering leaders utilize technical, human, and conceptual skills may provide a foundation for improving engineering leadership programs to prepare leaders for leadership positions.

Effective leadership. Fiedler (1981) looked at effective leadership in a seminal article which considered traits and skills in leaders. Fiedler (1981) noted the significant amount of prior research on traits that make up an effective leader which included physical traits such as height and personality traits such as charisma but noted that many of the findings did not make the connection to effective leadership. Fiedler (1981) suggested future research focus in the area of ability-based leadership which includes the development of skills such as knowledge, problem-solving, and sound judgments. Since the seminal article by Fiedler (1981), research has continued on effective leadership with some researchers applying it to the engineering field.

The literature within the realm of engineering leadership makes connections between leadership skills and effective leadership (Hickman & Akdere, 2018; Rottmann et al., 2018). Hickman and Akdere (2018) pointed out the need for continued research on effective leadership, which may help the ever-growing information technology field to create best practices in leadership development. With the increased dependency on technology in the workplace, effective leadership within information technology has become important for the survival of organizations, thus researchers need to continue to explore leadership capabilities (Hickman & Akdere, 2018).

Similar to the concerns raised by Northouse (2018) regarding the utilization of skills, Rottmann et al. (2018) noted limitations in the current research on effective leadership, specifically within the engineering industry. Rottmann et al. (2018) suggested additional research to better understand effective leadership by uncovering how engineering leaders developed leadership skills. Thus, by conducting a study focused on how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions may add to the body of knowledge around effective leadership.

Leadership development. Northouse (2018) postulated that a skill-based approach to leadership is lacking application in training packages in real-world settings. Instead, organizations may focus on the trait and behavioral approaches when assessing leadership (Northouse, 2018). Leadership development is an important consideration due to the aging workforce which leaves a gap in the leadership pipeline (Maurer & London, 2015). There is a wide variety of literature on leadership development with some focusing on industry settings (AbuJbara & Worley, 2018; Grimm, Watanabe-Galloway, Britigan, & Schumaker, 2015; Maurer & London, 2015; Pons, 2015; Simmons, Clegorne, & Woods-Wells, 2017) and others considering higher education settings (Carfagno, 2017; Lopes, Gerolamo, Del Prette, Musetti, & Del Prette, 2015). Within the higher education setting, some universities have started incorporating leadership into engineering disciplines (Carfagno, 2017). Carfagno (2017) pointed out the importance of developing leadership skills within higher education but called out the challenges to meet all the curriculum demands within an engineering-focused degree.

Lopes et al. (2015) also noted the value of developing leadership skills within undergraduate courses in the engineering discipline. Learning non-technical skills such as interpersonal skills and problem-solving skills may help students be better prepared for the work environment (Lopes et al., 2015). Based on the results of their studies, both Carfagno (2017) and Lopes et al. (2015) recommended additional research in the area of leadership development within the engineering discipline. While some researchers only considered leadership development within higher education, others indicated a need for ongoing training in leadership within organizations (Simmons et al., 2017).

Within the engineering industry setting, Simmons et al. (2017) indicated a discrepancy between the engineering curriculum at the university level compared to the need for leadership skills in professional practice. A need for leadership development using evidence-based information to create curriculum led the researchers to investigate existing literature on leadership approaches (Simmons et al., 2017). The researchers found the skilled approach to leadership development in engineering was occasionally present but should be a more focused, lifelong process for engineering leaders (Simmons et al., 2017).

Pons (2015) also mentioned the lack of time in undergraduate engineering programs to obtain enough emphasis on leadership skills. Given this dilemma, Pons (2015) conducted a qualitative study that surveyed professional engineers to gain a better understanding of the importance of leadership skills at different levels of career progression. While the information obtained from the study provided insight into what skills were important at various levels of career progression, Pons (2015) indicated future studies should focus on specific disciplines within engineering.

Other studies have taken a broader view on leadership development and with some focusing on different industries. For example, AbuJbara and Worley (2018) conducted a review of the literature to analyze leadership development and provided recommendations for future directions in leadership training. The researchers found a need for more attention to the development of soft skills, which was lacking in leadership development training programs (AbuJbara & Worley, 2018). Based on the need for additional soft skills in leadership development training programs, AbuJbara and Worley (2018) suggested that training programs be tailored to the specific discipline based on real-world scenarios.

Understanding the utilization of skills within engineering leadership positions may contribute to better training programs for upcoming engineering leaders. Grimm et al. (2015) considered leadership development within the health care industry by conducting a qualitative study on leadership skills. The researchers focused on a trait leadership approach within this study based on leadership models such as transformational leadership, servant leadership, collaborative leadership, emotional intelligence, and appreciative leadership which resulted in the identification of six domains needed for leadership (Grimm et al., 2015). Based on the results, the researchers suggested continued research on the skills needed for leadership by gaining insights from within different work industries.

Technical, human, and conceptual skills. Katz (1955) provided the initial view of the need for technical, human, and conceptual skills to be effective in management.

Since the seminal article by Katz (1955), researchers have continued to examine the aspects of technical, human, and conceptual skills. The Katz three skills model is generic enough to apply to various industries (Uhr, 2017), but there is limited research connecting the three skills model to engineering leadership (Medcof, 2017).

Since the seminal work on technical, human, and conceptual skills (Katz, 1955) and the empirical study completed by Mann (1965), researchers have been replicating and adding onto the three skills of effective leadership concept. Mumford et al. (2000) used the skill-based approach based on Katz's (1955) three skills model and suggested additional components such as individual attributes (cognitive ability, motivation, and personality) feed into competencies/skills, which result in leadership outcomes such as effective problem-solving and performance. While the Mumford et al. (2000) skill model added to the overall picture of effective leadership, the skills portion of the model stayed in line with Katz's (1955) three skills model.

Technical skills. According to Katz (1955), technical skills include the ability to be proficient at a specific activity and have specialized knowledge within a discipline. Katz (1955) initially posited that technical skills may be more important at lower levels of management and become less relevant in higher-level leadership positions. Mann (1965) conducted studies using Katz's (1955) three skills model which provided empirical evidence to support the model. In 2009, Katz updated his perspective on the utilization of technical skills and suggested the need for technical skills at all levels of management. Hence, the discussion continues, regarding the utilization of technical skills in leadership positions.

For example, Kearns et al. (2015) conducted a qualitative study to explore how chief executive officers in non-profit organizations utilize skills within leadership positions and found the leaders identified technical skills as an important aspect of their role. The results of the study by Kearns et al. (2015) supported the updated ideas from Katz (2009) that suggested technical skills were important at all levels of leadership. In contrast, Medcof (2017) conducted a review of research on technology management and found an abundance of literature regarding the need for technical skills in lower-level supervisory positions, but a lack of research on utilization of technical skills in higher-level leadership positions. Thus, there are discrepancies in the literature on the utilization of technical skills within various levels of leadership.

Two years after Kearns et al. (2015) published their findings, Kalliamvakou et al. (2017) considered leadership skills within technology management by conducting a mixed-method study with engineers and engineering managers at Microsoft. The researchers discovered engineering managers needed enough technical skills to guide the team, but technical skills were not the most important skill in leadership positions and suggested further research on the utilization of technical skills in leadership positions (Kalliamvakou et al., 2017). Leaders who have strong technical skills may over-utilize the skillset by solving technical problems that subordinates could handle (Capretz & Ahmed, 2018).

In contrast to the Kalliamvakou et al. (2017) study, Rottmann et al. (2015) concluded technical mastery was one of the important skills needed in engineering leadership based on a qualitative study with junior engineers, senior engineers, and human resources professionals. Racine (2015) suggested engineering leaders have a balance of technical skills and leadership skills but noted the need for further research by gaining insights from technical professionals. Perry et al. (2017) described a disconnect in the engineering leadership field due to an overemphasis on technical skills and lack of leadership training.

There are discrepancies in the literature regarding the importance of technical skills in leadership positions, and specifically within engineering leadership, which prompts the need to continue research in this area (Kalliamvakou et al., 2017; Racine, 2015; Rottmann et al., 2015). In addition to considering the perspectives on technical skills in leadership positions, researchers have also studied the importance of human skills compared to technical skills. Some researchers concluded technical skills were more important than human skills (Elegbe, 2015; Rottmann et al., 2015) while other researchers identified human skills as a top priority in leadership positions (Capretz & Ahmed, 2018; Kalliamvakou et al., 2017).

Human skills. Katz (1955) distinguished between technical and human skills by describing how technical skills relates to working with objects or processes compared to human skills which focus on people. Peterson and Van Fleet (2004) extended the definition of human skills initially created by Katz (1955) by making a connection between human skills and people-related skills. People-related skills may include teamwork, communication, and dealing with workplace situations such as conflict and climate (Peterson & Van Fleet, 2004).

There are many variations to the concept of human skills. For example, Capretz and Ahmed (2018) discussed human skills within the context of soft skills such as collaboration, communication, and similar interpersonal skills. Boyatzis et al. (2017)

described human skills within the context of emotional and social intelligence with an emphasis on the importance of emotional and social intelligence in the engineering discipline. Social and emotional intelligence had a strong correlation with effective engineering leadership (Paul & Falls, 2015).

Emotional intelligence has been the focus of many researchers throughout the past 20 years. For example, Salovey and Mayer (1990) created the original concept of ability-based emotional intelligence and suggested people have various levels of intelligence with the ability to understand the behaviors of others. Goleman (2000) built on the ideas of Salovey and Mayer and asserted that emotional intelligence was more important than intelligent quotient (IQ), thus people could learn how to be emotionally intelligent through training programs.

Leaders in organizations can train employees on emotional intelligence through classes, but the employees need to apply additional effort to refine the skills (Goleman, 2000). Goleman (2000) looked at numerous large organizations, such as Lucent Technologies and British Airways, to analyze competency models which resulted in identifying five components of emotional intelligence: self-awareness, empathy, motivation, social skills, and self-regulation. Goleman (2000) noted technical skills and intelligent quotient (IQ) are important for strong leadership, but emotional intelligence is another factor to consider for effective leadership. Since that time, many researchers have chimed in on the theory of emotional intelligence (Caruso et al., 2016; Mayer et al., 2016).

Caruso et al. (2016) pointed out the need for continued research on emotional intelligence, specifically in the workplace and at the university level, to refine the definition and justify the need for training in emotional intelligence. Emotional intelligence may have differences within various cultural contexts, so it is important to uncover the moderators that contribute to the differences (Caruso et al., 2016). Mayer et al. (2016) updated findings on emotional intelligence to include new concepts such as the concept of reasoning. The researchers (Mayer et al., 2016) added various types of reasoning to the original emotional intelligence model, such as the ability to recognize cultural differences, ability to differentiate between mood and emotions, and understanding how a person may feel within certain contexts (Mayer et al., 2016).

Based on the seminal work of Salovey and Mayer (1990) and Goleman (2000), researchers have branched off in different directions such as emotional intelligence in relationship to career satisfaction, career success, leadership effectiveness, job engagement, job performance, engineering leadership, and training with a specific focus on the engineering field (Boyatzis et al., 2017; Elegbe, 2015; Lopes, 2016).

Researchers have considered emotional intelligence within the engineering discipline (Boyatzis et al., 2017; Elegbe, 2015). As one example, Boyatzis et al. (2017) explored the relationship between emotional intelligence and the effectiveness of engineers with a correlational quantitative study of 40 engineers using both peer-reported surveys and self-assessment surveys. Boyatzis et al. (2017) used instruments to measure both emotional intelligence and cognitive intelligence, but also considered personality and relationships. The researchers used instruments, such as the Emotional and Social Competency Inventory (ESCI), to gain a peer-evaluated perspective of emotional intelligence level, the Utrecht Work Engagement Scale (UWES) to gain a self-assessment of the engineer's job engagement, the Raven's Advanced Progressive Matrices to measure cognitive intelligence, the NEO Personality Inventory (NEO-FFI) to provide a self-report of personality traits, and the PNEA survey to measure the quality of relationships (Boyatzis et al., 2017). The researcher found a significant relationship between higher levels of emotional intelligence and engineer effectiveness (Boyatzis et al., 2017). Based on the results of this study, the researchers suggested additional research between emotional intelligence and engineers to gain a more in-depth understanding of the factors that contribute to the effectiveness of engineers (Boyatzis et al., 2017).

Elegbe (2015) also considered the relationship between emotional intelligence and engineers but focused his study on emotional intelligence and engineering skills in relation to job performance and effective leadership. The researcher conducted a qualitative case study using structured interviews on recent graduates and managers to gain an understanding of each group's perceptions of emotional intelligence in relation to job performance and leadership effectiveness (Elegbe, 2015). The study spanned three years and included 265 engineering graduates from the National Youth Services Corps program and 72 managers from various engineering industries, such as construction, information technology, and telecommunications (Elegbe, 2015).

Like the findings from Boyatzis et al. (2017), Elegbe (2015) found the engineering managers felt emotional intelligence was a key component to engineering effectiveness from both a job performance and leadership perspective. In contrast, engineering students did not perceive emotional intelligence as an important factor in job performance or leadership effectiveness (Elegbe, 2015). The engineering students felt that technical skills were more important in job performance and leadership effectiveness than having emotional intelligence skills (Elegbe, 2015). The researcher (Elegbe, 2015) concluded that the college students lacked exposure to emotional intelligence training, and thus may have a blind eye to the value of the emotional intelligence skills. Based on the results of the study, Elegbe (2015) suggested emotional intelligence training be part of the engineering student's college curriculum and recommended that researchers conduct future research within corporations to gain a better understanding of the value of emotional intelligence through real-world experiences, based on the worker's knowledge about the global economy.

Conceptual skills. While the existing literature within engineering leadership has a heavy focus on technical and human skills, there is limited research on the utilization of conceptual skills (Medcof, 2017). Katz (1955) defined conceptual skills as "the ability to see the enterprise as a whole" (p. 35). In other words, leaders who have conceptual skills can make connections between various components and can set the stage for the future direction of the organization (Katz, 1955). Building on the previous analogy that related technical skills to objects and human skills to people, conceptual skills utilize ideas (Northouse, 2018). Katz (1955) originally suggested that conceptual skills are most important at the top-levels of management and less needed in lower management positions. Since that time, Katz (2009) updated his ideas on conceptual skills and stressed the need to develop conceptual skills throughout a career.

Researchers have studied conceptual skills in other disciplines, such as qualitative research by Harrison et al. (2018) who interviewed retail pharmacy entrepreneurs and employees on leadership skills. The researchers suggested a list of conceptual skills which included analytical, idea generation, problem-solving, envisioning, strategic planning, and decision-making skills (Harrison et al., 2018). While the study focused on entrepreneurial leadership, the researchers noted that the findings may shed light on skills that lead to effective leadership across other domains (Harrison et al., 2018).

Matteson et al. (2016) considered Katz's (1955) three skills within academic librarianship and questioned if conceptual skills fall more into the soft skills area. After additional consideration, the researchers noted the analytical ability associated with conceptual skills may fit within soft skills but could also stand alone as long as the characteristics within the area of conceptual skills were well defined. Matteson et al. (2016) noted the importance of clearly defining the characteristics of conceptual skills. Kearns et al. (2015) also felt it was important to provide the context of conceptual skills and summarized conceptual skills as "the leader's ability to solve ill-defined, novel, and complex organizational problems" (p. 718).

Mahdavian, Wingreen, and Ghlichlee (2016) conducted a mixed-method study to consider the effect of technical, human, and conceptual skills in project success. The researchers provided characteristics of conceptual skills such as the ability to solve problems, analytical thinking planning, goal setting, and ability to analyze results (Mahdavian et al., 2016). In the study, the researchers identified technical, human, and conceptual skills as the independent variables and the success of the enterprise resource planning (ERP) system as the dependent variable (Mahdavian et al., 2016). The results of the study showed a relationship between technical skills and human skills with the success of the ERP system, but conceptual skills did not factor in as being relevant (Mahdavian et al., 2016). Based on the initial findings, the researchers conducted a qualitative study via interviews to gain more details from the sample (Mahdavian et al., 2016). The results of the interviews provided the researchers with more detail on the characteristics within the conceptual skills area such as change management, risk management, crisis management, strategic planning, and problem-solving (Mahdavian et al., 2016). The findings from this study may provide a foundational description of conceptual skills that can be used in future studies.

Nix and Bigham (2015) used a case study design to gain a perspective on leadership skills needed in an interim superintendent position in a Texas school district. From a conceptual skills perspective, the researchers identified the value of real-world experience within the Texas school district as a conceptual skill but noted that this classification may be specific to the case and may not generalize to other situations (Nix & Bigham, 2015). The researchers also provided a summary of conceptual skills which includes the ability to work with concepts and abstract ideas (Nix & Bigham, 2015).

Medcof (2017) considered Katz's (1955) three skills model in a study that reviewed literature within technology management as the first step toward a better understanding of skills utilized at different levels of management. The researcher suggested additional research to gain a more in-depth analysis of the skills utilized at various leadership levels (Medcof, 2017). While various studies have considered conceptual skills within leadership, there is a lack of research within the engineering leadership discipline.

Methodology. The previous section provided an overview of the existing literature on engineering, leadership, and technical, human, and conceptual skills based on current studies. In this section, the methodologies of current studies will be discussed to show how researchers have utilized different methodologies in studying similar phenomena or topics. This review of methodologies will provide a foundation for the methodology the researcher utilized in the study.

The rationale for the differences between a quantitative and a qualitative study can be based on the focus of the study. In a quantitative study, the focus is on investigating relationships between variables, in contrast to a qualitative study where researchers investigate the how and why of the phenomenon (Yates & Leggett, 2016). There is a combination of qualitative, quantitative, and mixed-method studies in the current research on engineering, leadership, and skills (Boyatzis et al., 2017; Elegbe, 2015; Hartmann & Jahren, 2015; Hendon et al., 2017; Kalliamvakou et al., 2017; Minh et al., 2017; Paul et al., 2018; Racine, 2015; Rottmann et al., 2016).

For example, Boyatzis et al. (2017) conducted a quantitative study that gathered data from 40 engineers in a multi-national manufacturing company. The focus of the study was to investigate the correlation between engineer effectiveness and emotional-social intelligence in addition to the correlation of engineer engagement with personality traits (Boyatzis et al., 2017). The researchers used several instruments such as the emotional and social competency inventory (ESCI), the Utrecht work engagement scale (UWES), the Ravens advanced progressive matrices, the NEO personality inventory, and the PNEA survey to gather data (Boyatzis et al., 2017). The researchers claimed the most significant result of the study was the correlation between emotional-social intelligence and engineer effectiveness, thus providing a foundation for additional research on skills needed in engineering (Boyatzis et al., 2017).

Hendon et al. (2017) also conducted a quantitative study focused on emotional intelligence with technology professionals and considered the correlation between emotional intelligence and communication among information technology professionals in the United States. The sample consisted of 109 participants who had worked in the information technology field for more than two years (Hendon et al., 2017). The researchers utilized the Schutte Self-Report Emotional Intelligence Test (SSEIT) and the Communication Adaptability Scale (CAS) instruments to gather data (Hendon et al., 2017). The researchers showed a positive correlation between emotional intelligence and communication skills but suggested further research be conducted to better understand the utilization of human skills within different technology positions (Hendon et al., 2017).

Minh et al. (2017) conducted a quantitative study within the telecommunications industry with a sample of 52 managers and 127 subordinates within the VNPT Group organization. The researchers created a 7-point Likert-type questionnaire as the instrument to rate the level of competencies in technical skills, learning work behavior, and innovative work behavior (Minh et al., 2017). The study resulted in the discovery that technical skills were considered important within technical management positions (Minh et al., 2017) which contradicts other researchers (Kalliamvakou et al., 2017; Katz, 1955). Minh et al. (2017) noted the limitations of only considering technical competencies and suggested other competencies be explored in future research.

In addition to the current research using quantitative methodologies, qualitative methodologies have also been utilized to explore leadership skills within the engineering discipline. For example, Elegbe (2015) conducted a qualitative study using interviews over three years with 265 engineering graduates and 72 managers from telecommunications, construction, and information technology organizations. The interviews consisted of questions focused on the utilization of hard skills (technical engineering skills) and soft skills (emotional intelligence skills) based on different positions within the organization (Elegbe, 2015). The researcher's findings were similar to Katz's (1955) claim that the importance of technical skills lessens as the leader progresses to higher leadership positions (Elegbe, 2015). Elegbe (2015) noted how the labor market within engineering continues to change and concluded it is valuable to continue to gain perspectives from corporations as engineering leadership needs evolve.

Hartmann and Jahren (2015) also researched engineering leadership using a qualitative methodology by conducting a two-phased study. The researchers analyzed data from full-time job postings within a university's career management system by searching for the word 'leadership,' which occurred in 982 of the job postings (Hartmann & Jahren, 2015). Hartmann and Jahren (2015) identified five categories of leadership from the job descriptions: applicant skills, influence/role, job title, development, and company qualities. The first two categories (applicant skills and influence/role) were carried forward to the second phase of the study (Hartmann & Jahren, 2015). The researchers conducted interviews in the second phase of the study to gather information from six leaders in the construction and electrical engineering disciplines (Hartmann & Jahren, 2015). The results provided leadership focused themes such as initiative/confidence, communication, interpersonal interactions, teamwork, and engagement which are desired in engineering positions (Hartmann & Jahren, 2015). The limitations of the study included a small sample in the second phase of the study and a limited number of engineering disciplines (Hartmann & Jahren, 2015). Hartmann and Jahren (2015) concluded that continuing to study engineering leadership skills within other disciplines such as engineering within the information technology field may continue to add to the body of knowledge on leadership skills in engineering.

Paul et al. (2018) attempted to advance the definition of engineering leadership by conducting a qualitative study using a survey sent to 163 current or previous university engineering students in Canada. The researchers posed an open-ended question regarding the definition of leadership within engineering which was analyzed using qualitative content analysis (Paul et al., 2018). Based on the analysis, the researchers suggested four themes: leading and influencing others, personal effectiveness, engineering competence, and collaboration which led to a definition of engineering leadership (Paul et al., 2018). Paul et al. (2018) noted how the subject of engineering leadership continues to grow yet has a lack of clarity on leadership skills. The researchers suggested the proposed engineering leadership definition may help establish a better understanding of leadership within engineering, but continued research is needed with industry professionals to gain a better understanding of engineering leadership (Paul et al., 2018).

Racine (2015) utilized a qualitative methodology to gain a better understanding of how scientists and engineers evolve into leaders by interviewing 20 managers within various scientific fields such as engineering, medical equipment and research, forestry, ecological services, chemistry, biological sciences, and geology. The researcher analyzed the data from the interviews and proposed three categories: individual identity development, group/organizational identity development, and social identity development (Racine, 2015). Racine (2015) suggested research continue in the area of leadership development by obtaining real-world experiences from professionals within technical positions.

Similarly, in 2015, Rottmann et al. also conducted a qualitative study on engineering leadership but, different from Racine (2015), the researchers focused on gaining a better understanding of engineering leadership by considering how engineers conceptualize leadership based on industry experience. The researchers conducted nine focus groups and seven interviews with a sample of junior engineers, senior engineers, and human resources professionals within engineering firms (Rottmann et al., 2015). Based on the results of the study, Rottmann et al. (2015) proposed a grounded theory on engineering leadership which consisted of technical mastery, collaborative optimization, and organizational innovation. The researchers noted the limitations of the study which included a focus within a specific geographic region and a lack of perspective from industry leaders, thus further research could include a sample of engineering leaders (Rottmann et al., 2015).

Shortly after the study by Rottmann et al. in 2015, Rottmann et al. (2016) conducted a follow-up mixed methods study on engineering leadership, which used surveys, focus groups, and semi-structured interviews as data sources. The researchers utilized a quantitative approach via survey research, sending surveys to 200 engineers and a subsequent qualitative approach with six focus groups with junior and senior engineers plus one semi-structured interview with human resource professionals (Rottmann et al., 2016). The researchers proposed five components of engineering leadership: mastery of engineering competencies, organizational awareness, motivation to drive innovative change, orientation towards public service, and the ability to help others learn (Rottmann et al., 2016). Rottmann et al. (2016) noted the diversity in responses based on the different groups that were interviewed which led to the suggestion that it would be valuable to gain the perspective of engineering leaders through in-depth interviews.

Kalliamvakou et al. (2017) also conducted a mixed-method study to gain a better understanding of what makes a great engineering manager. The researchers started with 37 semi-structured interviews with engineers and managers at Microsoft and then created a survey which resulted in 563 responses from engineers and managers (Kalliamvakou et al., 2017). The analysis of the data from the mixed-method study led the researchers to propose attributes that the sample felt were important in engineering leadership positions (Kalliamvakou et al., 2017). The researchers suggested future exploration of the skills utilized in engineering leadership positions within different industries to further the empirical research on engineering leadership (Kalliamvakou et al., 2017).

The previous studies used quantitative, qualitative, and mixed methods to research a combination of engineering, leadership, and skills. The quantitative studies (Boyatzis et al., 2017; Hendon et al., 2017; Minh et al., 2017) were focused on comparing various leadership attributes in engineering such as communication, emotional-social intelligence, personality, effectiveness, engagement, technical skills, and work behavior. While these studies added to the body of knowledge from a comparison and correlation perspective, the studies did not consider the personal experiences of engineering leaders.

The qualitative studies (Elegbe, 2015; Hartmann & Jahren, 2015; Paul et al., 2018; Racine, 2015; Rottmann et al., 2015) involved consideration of a variety of perspectives on engineering leadership by conducting interviews, open-ended surveys, focus groups, and analyzing job postings. The researchers were in general agreement on the need for continued exploration of engineering leadership and specifically gaining insights from the real-world experiences of engineering leaders within the various disciplines of engineering (Elegbe, 2015; Hartmann & Jahren, 2015; Paul et al., 2018; Racine, 2015; Rottmann et al., 2015).

For example, Hartmann and Jahren (2015) explored engineering leadership using a qualitative methodology by interviewing six leaders in construction and electrical engineering. While the researchers discovered skills used by leaders within the construction and electrical engineering discipline, they suggested additional research in other disciplines of engineering to continue exploring skills needed in engineering leadership positions (Hartmann & Jahren, 2015).

In the same year, Rottmann et al. (2015) conducted a qualitative study on engineering leadership with engineers and human resources professionals. The researchers created a grounded theory on engineering leadership but noted limitations in the study based on geographical region and lack of perspectives from leaders within engineering organizations (Rottmann et al., 2015).

Paul et al. (2018) also used a qualitative methodology to explore engineering leadership by surveying 163 current or previous engineering students. While Paul et al. (2018) provided additional insights into engineering leadership, they noted the need to gain insights from professionals within industries. While these qualitative studies explored engineering leadership, all of the researchers called for additional qualitative studies to further the area of engineering leadership by gaining insights from industry leaders. The researchers were in general agreement on the need for continued exploration of engineering leadership and specifically gaining insights from the real-world experiences of engineering leaders within the various disciplines of engineering (Elegbe, 2015; Hartmann & Jahren, 2015; Paul et al., 2018; Racine, 2015; Rottmann et al., 2015).

Kalliamvakou et al. (2017) and Rottmann et al. (2016) conducted mixed-method studies to further the definition of engineering leadership and consider what makes a great engineering manager. The researchers suggested the need for further exploration of the skills needed for leaders within engineering through in-depth interviews to continue advancing leadership within engineering (Kalliamvakou et al., 2017; Rottmann et al., 2016). Based on the results and suggestions from both the qualitative and mixed-method studies (Elegbe, 2015; Hartmann & Jahren, 2015; Kalliamvakou et al., 2017; Paul et al., 2018; Racine, 2015; Rottmann et al., 2016), a common need emerged to continue exploration of skills needed in engineering leadership, with some researchers such as Kalliamvakou et al. (2017), suggesting a focus on engineering leadership which influenced the researcher to focus on a qualitative methodology for the proposed study. Conducting a qualitative study to explore how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions may fill the need to provide additional knowledge of skills needed in engineering leadership.

Data sources. The data sources from prior research studies influenced the type of data sources to be used in the study based on the use of a qualitative methodology. For example, Elegbe (2015) conducted structured interviews with 265 engineering graduates and 72 managers within various types of organizations such as construction, telecommunications, information technology, and flour mills for over three years. Based on the results of the study, Elegbe (2015) suggested further research through the involvement of corporations to understand the local experiences of engineering leaders.

In the same year, multiple researchers used qualitative research studies to explore various aspects of leadership within engineering using data sources such as interviews, job posting data, and focus groups (Hartmann & Jahren, 2015; Racine, 2015; Rottmann et al., 2015). Hartmann and Jahren (2015) explored leadership themes in engineering by analyzing 982 job postings for over six years based on the word ‘leadership’ within the job descriptions and then conducting interviews with six people involved in hiring and/or supervising entry-level engineers. The limitations of the study by Hartmann and Jahren (2015) were identified as a small sample size which did not allow for an in-depth understanding of leadership competencies. Thus, additional studies on leadership skills using a qualitative methodology could provide further details to gain a deeper understanding of an engineering leader’s perspective.

Racine (2015) and Rottmann et al. (2015) both focused on interviews as the data source to capture the evolution of engineers into leadership positions. While the researchers were able to propose engineering leadership skills, the researchers were in general agreement that additional research was needed to describe how leadership skills were utilized based on real-world experiences of leaders (Racine, 2015; Rottmann et al., 2015). The prior studies shaped the decision in the study to focus on exploring leadership skills in engineering by collecting data via the Northouse Skills Inventory Survey (2018) and in-depth interviews to capture real-world experiences from an engineering leader perspective.

Summary

The focus of the literature review and theoretical foundation was to show the progression of leadership and skills in relation to engineering as a basis for additional research on the utilization of technical skills, human skills, and conceptual skills in leadership positions by engineering leaders. The theoretical foundation was based on Katz's (1955) three skills model of effective management that the researcher used to develop the research questions within the study. Katz's (1955) three skills model proposed that managers utilize technical skills, human skills, and conceptual skills at various levels of leadership. The research questions are directly aligned with the Katz (1955) model and consist of: (R1) How do engineering leaders utilize technical skills in their leadership positions, (R2) How do engineering leaders utilize human skills in their leadership positions, and (R3) How do engineering leaders utilize conceptual skills in their leadership positions.

The literature review started with the background in engineering which showed how the field of information technology has progressed from the past to the current research on engineering leadership skills. Organizations rely on technology to stay competitive, thus it is valuable to continue research on the skills needed in engineering leadership positions (Broy, 2018; Capretz & Ahmed, 2018; Cetindamar et al., 2016). This researcher also provided an overview on engineering leadership research to show progress that has been made toward defining the concept of leadership within engineering and set the stage for continued research on engineering leadership (Kalliamvakou et al., 2017; Perry et al., 2017; Racine, 2015; Rottmann et al., 2015).

The second major theme focused on leadership, including leadership approaches, effective leadership, and leadership development. Northouse (2018) suggested a skill-based leadership approach related to Katz's (1955) three skills model. This section also showed the progress of effective leadership through the lens of the engineering field. Hickman and Akdere (2018) noted the importance of effective leadership in the information technology field due to the increased dependency on technology in the global business world. Northouse (2018) and Rottmann et al. (2018) indicated limitations in the current research on skills needed for effective leadership and suggested continued research on the utilization of skills in leadership positions. Based on the lack of research on effective leadership skills specifically within the engineering discipline (Grimm et al., 2015), this study added to the body of knowledge by gaining insight on the utilization of technical skills, human skills, and conceptual skills in leadership positions by engineering leaders.

The final theme showed ongoing research that utilized Katz's (1955) three skills model which included technical, human, and conceptual skills that have been studied in relation to engineering. The current research showed discrepancies among researchers on the utilization of technical skills in engineering leadership positions (Elegbe, 2015; Capretz & Ahmed, 2018; Kalliamvakou et al., 2017; Rottmann et al., 2015). In the area of human skills, Boyatzis et al. (2017) and Elegbe (2015) considered emotional intelligence within engineering and suggested continuing studies through descriptions of experiences from leaders within engineering. Limited research has focused on conceptual skills within engineering leadership. Medcof (2017) considered conceptual skills in technology management through a review of the literature but did not obtain descriptions from leaders within engineering.

The background of the problem stems from continued growth in the information technology field and specifically the growth of leadership positions (Bureau of Labor Statistics, 2019). There is a concern among researchers on the lack of understanding of leadership skills needed with the information technology field (Hickman & Akdere, 2018). Based on the theoretical foundation, review of literature, and background on the problem, research is needed on how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions (Boyatzis et al., 2017; Kalliamvakou et al., 2017; Medcof, 2017; Racine, 2015; Rottmann et al., 2016).

While researchers provided recommendations for skills needed in engineering leadership positions, the focus was not on leaders (Boyatzis et al., 2017; Rottmann et al., 2016). Research from a qualitative descriptive perspective that utilizes surveys and in-depth interviews provided additional insights based on descriptions of leadership skills utilized by engineering industry leaders in the information technology field. The population of interest in the study was all engineering leaders within the information technology field in the United States. The study attempted to provide insight into the problem: It was not known how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions.

The purpose of this chapter was to synthesize information from prior literature to address what research has been completed and show why research is still needed to inform the problem statement for the study. The next chapter will focus on the methodology of the study including the design, population, sample, and data analysis procedures. The researcher will also address trustworthiness and ethical considerations for the study.

Chapter 3: Methodology

Introduction

The purpose of this qualitative descriptive study was to explore how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions within the information technology field in the United States. The increased utilization of technology with billions of devices and users has moved the discipline of engineering to the forefront of business priorities (Broy, 2018). As the need for technology grows, the need for numerous positions within the engineering discipline grows, including the need for engineering leaders. The reliance on technology is related to the importance of engineering leadership positions to help establish competitive strategies within organizations (Broy, 2018). The study added to the body of knowledge by providing new insights into skills utilized in engineering leadership positions.

In this chapter, the plans for the study based on a qualitative methodology and descriptive design are presented. The statement of the problem and research questions will be presented, followed by details on the research methodology, research design, population, sample size selection, and sources of data. Trustworthiness, which Birt, Scott, Cavers, Campbell, and Walter (2016) noted as the foundation of high-quality qualitative research with a focus on data collection and analysis, will also be addressed. The data collection section of this chapter will include the steps that were followed to gather data for analysis and to address the research questions. The data collection steps will have enough detail to be replicated by another researcher. The last section of the chapter will include data analysis procedures, ethical considerations, limitations, delimitations, and a summary.

Statement of the Problem

It was not known how engineering leaders described the utilization of technical skills, human skills, and conceptual skills in their leadership positions. The problem statement addressed the gap in the literature that suggested further research was needed into how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions (Boyatzis et al., 2017; Kalliamvakou et al., 2017; Medcof, 2017; Racine, 2015; Rottmann et al., 2016). According to Medcof (2017), leadership development within technical disciplines such as engineering needs a more systematic, integrated approach to develop a leadership pipeline. The research into the utilization of skills in leadership positions by engineering leaders in this study provided additional knowledge in engineering leadership.

In addition to providing additional knowledge in engineering leadership, the problem statement covered the need to consider discrepancies in the literature regarding the utilization of technical, human, and conceptual skills within engineering leadership positions. Kalliamvakou et al. (2017) researched the skills needed in engineering leadership and found that respondents in the study did not think technical skills were as critical as soft skills. In contrast, Rottmann et al. (2015, 2016) conducted two studies that showed technical competency as a key skill in engineering leadership positions. The importance of conceptual skills has also been debated in the literature. For example, Katz (1955) initially posited conceptual skills were most important at the top-levels of leadership, but later Katz (2009) suggested conceptual skills may be needed at all levels of leadership. The study shed light on the discrepancies in current research.

Research Questions

The phenomenon of this study was the utilization of technical skills, human skills, and conceptual skills in leadership positions by engineering leaders. Authors of recent literature addressed the phenomenon of technical skills and human skills within engineering leadership, but the research samples did not include software engineering leaders (Rottmann et al., 2016); the research contributed to addressing this deficit. Also, while some studies explored conceptual skills in leadership positions, the samples were from leaders in industries such as retail pharmacy and CEO's in non-profit organizations (Harrison et al., 2018; Kearns et al., 2015). Hence, research was needed to explore the utilization of technical, human, and conceptual skills with a sample of software engineering leaders to improve leadership development in the engineering field.

In addition to the potential to help organizations develop upcoming leaders, the results of the study expanded engineering leadership theories (Kalliamvakou et al., 2017; Rottmann et al., 2016) and further the exploration of Katz's (1955) three skills model of effective leadership within engineering. Katz's (1955) three skills model for effective leadership included the utilization of technical skills, human skills, and conceptual skills. The research questions guiding the study were designed to align with the Katz (1955) model.

The overarching research question was: How do engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions? The following specific research questions guided the data collection:

RQ1: How do engineering leaders describe the utilization of technical skills in their leadership positions?

RQ2: How do engineering leaders describe the utilization of human skills in their leadership positions?

RQ3: How do engineering leaders describe the utilization of conceptual skills in their leadership positions?

A qualitative methodology and descriptive design were selected due to the need to capture real-world descriptions of skills utilized in engineering leadership positions. The nature of the phenomenon was the utilization of technical skills, human skills, and conceptual skills in leadership positions by engineering leaders. Sandelowski (2000) indicated qualitative descriptive studies can be used to describe a phenomenon in everyday terms. Therefore, a qualitative descriptive approach was effective for answering the research questions because the sample described how they utilize technical skills, human skills, and conceptual skills in their leadership positions based on real-world experiences.

Two data sources, the Northouse Skills Inventory Survey (2018) and in-depth interviews, were used to gather data to address the research questions. The first data source was the Northouse Skills Inventory Survey (2018), which contained 18 statements that describe the utilization of either technical, human, or conceptual skills. The questions in the Northouse Skills Inventory Survey (2018) were divided into six statements for each of the three skills – technical, human, and conceptual. The Northouse Skills Inventory Survey (2018) was the first step in capturing information from participants on the utilization of each skill in their engineering leadership positions.

The second data source consisted of in-depth interviews. The researcher developed the interview questions based on the Katz's (1955) three skills model and information from prior engineering leadership studies (Boyatzis et al., 2017; Kalliamvakou et al., 2017; Medcof, 2017; Racine, 2015; Rottmann et al., 2016). Information from the Northouse Skills Inventory Survey (2018) and the in-depth interviews provided insight into the utilization of technical, human, and conceptual skills by engineering leaders.

Research Methodology

A qualitative methodology was selected for the study. A qualitative methodology was the best approach for the study due to the inductive nature of the phenomenon to gain insight into the utilization of technical skills, human skills, and conceptual skills in leadership positions by engineering leaders. Qualitative methodology is used when the researcher is interested in capturing the participant's experiences in a natural setting (Yilmaz, 2013). Obtaining descriptions of the utilization of skills from engineering leaders in a real-world context may lead to improvements in engineering leadership. Merriam and Tisdell (2016) claimed the value of using a qualitative methodology is based on the rich information gathered from the participants that can be used to make improvements within organizations. The study used an inductive process with the researcher as the instrument to gather data on how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions.

In contrast to a qualitative methodology, the emphasis of a quantitative methodology is on investigating cause and effect through manipulating independent variable(s), exploring the relationships of pre-selected variables, or assessing the distribution of attributes using numbers and statistical analysis (Merriam & Tisdell, 2016). While a qualitative methodology is inductive, a quantitative methodology is deductive; a hypothesis based on an existing theory is developed and tested (Yilmaz, 2013). Quantitative research is focused on relationships or measurements between variables from an objective perspective based on statistical results of pre-constructed instruments (Yilmaz, 2013). Quantitative methodologies can provide broad and generalizable findings but do not delve into the individual experiences of participants (Yilmaz, 2013). The purpose of the study was to explore how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions. The focus of the study was not on quantifying variables, doing statistical analysis, or exploring the relationship between variables through hypothesis testing. Key variables cannot be pre-established because they are not yet known, so a quantitative methodology was not applicable.

Current empirical research within the realm of engineering leadership was also considered when determining the type of methodology for the study. A combination of studies supported the choice of a qualitative methodology in the study (Elegbe, 2015; Hartmann & Jahren, 2015; Paul et al., 2018; Rottmann et al., 2015). For example, Elegbe (2015) conducted a qualitative study by interviewing engineers and managers on the utilization of hard skills (e.g. technical skills) and soft skills (e.g. emotional intelligence). The findings were similar to Katz's (1955) claim that the utilization of hard skills decreased, and soft skills increased as engineers progressed into leadership positions, but ongoing research was needed to gain perspectives from engineering leaders within other organizations (Elegbe, 2015). Insights from engineering leaders via a qualitative methodology provided additional information on the utilization of skills in leadership positions.

Research Design

The researcher chose a qualitative descriptive design for the study to explore how engineering leaders described the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions. Given the need to explore the descriptions from engineering leaders, a descriptive design was best suited for this study. Colorafi and Evans (2016) pointed out that qualitative descriptive studies are a naturalistic type of inquiry. In other words, the research is done in a natural setting where the researcher can obtain a comprehensive descriptive summary of what exists, in everyday terms (Lambert & Lambert, 2012). Obtaining rich descriptions from participants who have experienced the phenomenon can provide an opportunity to increase knowledge and improve learning opportunities for others (Bradshaw, Atkinson, & Doody, 2017). Thus, a qualitative descriptive design provided rich descriptions of engineering leaders' utilization of technical, human, and conceptual skills based on their real-world experiences.

Before selecting a qualitative descriptive design, other qualitative designs were considered, such as case studies, phenomenological, grounded theory, and narrative designs. Bradshaw et al. (2017) described the grounded theory as a discovery approach, a case study as exploring a process, and phenomenology as describing an experience. Each of these designs differs from a qualitative descriptive approach where the researcher focuses on capturing a detailed description of a phenomenon (Bradshaw et al., 2017).

A case study design was not selected because the focus of the study does not need to be bound by space or time. Percy et al. (2015) defined a case study as an in-depth investigation into a case that has clearly defined boundaries. The boundaries of the case provide parameters for data collection and analysis based on a specific location or timeframe (Harrison et al., 2017). The focus of the study was to capture descriptions of the utilization of technical, human, and conceptual skills from engineering leaders in a naturalistic setting that does not need boundaries.

The researcher initially considered a phenomenological design for the study but determined the focus of the study was not on capturing lived experiences of a specific event. A phenomenological design is appropriate to use when the researcher is interested in capturing a specific event or activity to gain an understanding of the meaning from participants (Sauro, 2015). Percy et al. (2015) pointed out a phenomenological design focuses on the lived experiences of the participants by considering the inner dimensions of the cognitive processes. In other words, the goal of a phenomenological design is to capture how participants find an event meaningful (Percy et al., 2015). Since the focus of the study was not to uncover the meaning of lived experiences based on an event or activity, the researcher ruled out the relevancy of a phenomenological design.

A grounded theory design was not selected for the study because the goal of the research was not to create a new theory or model. Sauro (2015) differentiated a grounded theory design from a phenomenological design by suggesting a grounded theory design attempts to explain a series of events. Percy et al. (2015) also indicated grounded theories are developed over time. The researcher did not plan to create a new theory or model on engineering leadership skills; therefore, a grounded theory design was not selected.

Finally, the components of a narrative design were reviewed to determine if it would be a fit for the study. Narrative design is a combination of stories told by participants to explain a life episode (Schmidt, 2018a). Sauro (2015) provided further explanation of a narrative design by noting how the researcher captures individual narratives from participants and weaves the narratives into an overall cohesive story. Since the goal of the study was to explore descriptions of the utilization of skills used by engineering leaders and not to capture stories from participants, a narrative design was not selected.

When a qualitative research method is used, the unit of analysis is considered the basic unit being studied, such as individuals, groups of people, or events (Yin, 2016). The unit of analysis for the study was engineering leaders who are currently in leadership positions. The unit of observation is where the data will be collected from within the target population (Schmidt, 2018). The unit of observation was the same for both data sources in the study. The unit of analysis and unit of observation were also the same: middle and top-level engineering leaders currently in leadership positions in the United States who have more than two years of leadership experience within the engineering discipline.

Population and Sample Selection

The general population for the study was all engineering leaders within the information technology field in the United States. The target population was all middle and top-level engineering leaders within the information technology field in the United States who had more than two years of leadership experience within the engineering discipline and were connected to the researcher's LinkedIn network. Eighty people in the researcher's LinkedIn network were identified as engineering leaders within the information technology field, based on their job title, and thus made up the target population for the study. The sample size consisted of 23 engineering leaders for the Northouse Skills Inventory Survey (2018) and 14 engineering leaders for the interviews, all of whom were in the information technology field in the United States, had more than two years of leadership experience, and were a part of the researcher's LinkedIn network.

The sample requirements were established based on Grand Canyon University's guidelines for qualitative descriptive studies. Qualitative descriptive studies need a minimum of 10 participants. Purposive sampling was used to recruit engineering leaders for the Northouse Skills Inventory Survey (2018) and the interviews. The researcher chose purposive sampling based on the participant's knowledge and expertise with the phenomenon (Etikan, Musa, & Alkassim, 2016). The researcher selected potential participants from a pre-developed list of engineering leaders who were connected to the researcher's LinkedIn page. Potential participants were contacted directly by the researcher via the LinkedIn Messenger functionality and provided information about the study. The participants responded to the researcher with an interest to participate by accessing SurveyMonkey to complete the Informed Consent, demographic information questionnaire, and Northouse Skills Inventory Survey (2018), in that unalterable sequence.

Purposive sampling is defined as, "the selection of participants or sources of data to be used in a study, based on their anticipated richness and relevance to the study's research questions" (Yin, 2016, p. 339). Purposive sampling is often used in qualitative studies because the participants are knowledgeable about the phenomenon being studied

(Etikan et al., 2016). For example, the middle and upper level engineering leaders who comprised the sample in the study had specific knowledge of the skills utilized in engineering leadership positions within the information technology field.

Site authorization was not needed for the study. Passive recruitment was used via the researcher's connections on LinkedIn. Site authorization is not required if the researcher is using passive recruiting via social media sites such as LinkedIn and is not using a closed group (GCU IRB Webinar, 2019).

Potential participants were contacted via the researcher's LinkedIn account for initial recruitment into the study. The researcher sent individual messages to engineering leaders via the LinkedIn Messaging function. Potential participants responded with an interest in participating in the proposed study by clicking on the SurveyMonkey link provided in the recruitment letter (see Appendix J) which included information on the purpose of the study, criteria for participating in the study (such as more than two years of engineering leadership experience), a description of research activities, risks, withdrawal procedures, and confidentiality.

The intent was to recruit at least 30 engineering leaders for the surveys to ensure there were enough participants for the interviews. In addition, the researcher initially planned on 15 engineering leaders for the interviews to account for attrition and data saturation. Out of the 80 engineering leaders who received a recruitment letter, 35 people responded, but not all of the potential participants took part in the study. Ten people out of the 35 replied to the researcher, via LinkedIn Messenger, to indicate they could not participate in the study due to lack of time, not residing in the United States, not being in an engineering leadership position, not having more than two years in engineering leadership, or no longer being employed. Twenty-five software engineering leaders accessed SurveyMonkey but two of the leaders did not complete the survey, which resulted in 23 participants in the Northouse Skills Inventory Survey (2018). Two weeks after the initial recruitment letters were sent to potential participants, the researcher followed up with potential participants who did not respond by sending additional messages via LinkedIn's Messaging feature. The researcher attempted to reach out to potential participants four separate times (every two weeks), but no additional participants opted to be involved in the study, resulting in a sample size of 23.

The study was not expanded to include people who were not in engineering leadership positions or who did not have more than two years of engineering leadership experience because, based on the gap, the study was focused on middle and upper level engineering leaders. Medcof (2017) pointed out that middle and upper level leaders provide a more in-depth view of leadership. Ultimately, the researcher was able to obtain 23 Northouse Skills Inventory Surveys (2018) from engineering leaders. Although the intended sample of 30 had not been achieved, a sample of 23 exceeded the minimum GCU requirement of 10 people for qualitative descriptive studies.

All participants had agreed to participate in an interview, if needed, when they signed their informed consent document. The researcher keep interviewing until the point of data saturation was reached. After each participant completed and returned a survey, the researcher contacted that participant to setup an interview. As the interviews progressed, the researcher started noticing repeating information after the 12th interview but completed two additional interviews to ensure saturation. Researchers may start seeing repetitive information with a larger sample size, which may indicate saturation and diminishing returns with additional participants (Mason, 2010). The researcher determined data saturation had been met with 14 interviews due to repetitive information and no new data after the 12th interview.

Sources of Data

Three sources of data were used for the study; one data source was used to capture demographic information on the participants and two data sources were used to collect data from the participants to answer the research questions. The sources of data used in the study included a demographic information questionnaire, the Northouse Skills Inventory Survey (2018) and in-depth interviews. Based on the results of the demographic information questionnaire and a signed consent form, the researcher received the Northouse Skills Inventory Survey (2018) from 23 engineering leaders. Out of the 23 engineering leaders who completed the Northouse Skills Inventory Survey (2018), the researcher conducted 14 in-depth interviews with engineering leaders to research saturation.

Data source 1: Demographic information questionnaire. The researcher created a demographic information questionnaire which provided a description of the sample (see Table 1). The demographic information provided data from the participants such as their current title as an engineering leader, years of experience in an engineering leadership position, validation of residing in the United States, and validation of their LinkedIn account.

Data source 2: Survey. Northouse (2018) created a Skills Inventory Survey to capture the leader's perceptions of the utilization of technical, human, and conceptual skills. The Northouse Skills Inventory Survey (2018) was used to explore skills engineering leaders utilize in leadership positions. The survey captured information from the participants to gain perceptions of the utilization of leadership skills from technical, human skills, and conceptual skills perspectives. The results of the survey were further explored in the in-depth interviews with 14 of the participants.

The Skills Inventory Survey (Northouse, 2018) contained 18 statements designed as a high-level summary of technical, human, and conceptual skills. The participants in the study rated each statement in the Skills Inventory Survey based on how the statement described their utilization of the skills within their leadership position in the organization. The Northouse Skills Inventory Survey (2018) was based on a Likert scale of one through five, with one being the least used skill and five being the most used skill. Northouse (2018) noted the abundance of questionnaires to assess leadership skills, including a comprehensive skills model developed by Mumford et al. (2000), but suggested the complexity of the instruments may be less valuable in a self-scoring scenario. Thus, Northouse (2018) provided a skills inventory which may provide leaders insight into their utilization of three specific skills, technical, human, and conceptual, from a self-assessment perspective. The participant's scores provided a high-level overview thier leadership strengths and weaknesses which were further discussed in the in-depth interviews.

Data source 3: Interviews. Concepts from Katz's (1955) three skills model and information from prior research studies completed by Boyatzis et al. (2017), Kalliamvakou et al. (2017), Medcof (2017), Racine (2015), and Rottmann et al. (2016) were used to develop the interview questions. The engineering leaders participated in in-depth interviews to elicit their descriptions of engineering leaders' utilization of technical, human, and conceptual skills in leadership positions. Interview questions were validated by documenting their alignment with Katz's (1955) three skills model.

A field test of the interview questions was completed, using four individuals who had leadership experience or had expertise in the engineering industry and were not involved in the sample. Before submitting the research proposal to AQR, defending the proposal, gaining IRB authorization, and conducting the study, the interview questions were modified based on the results of the field test. Details of the field test are documented in Appendix I. The alignment table (see Appendix H) shows the relationship between the research questions, Northouse Skills Inventory Survey (2018) items (see Appendix E), and semi-structured interview questions (see Appendix F) such as questions about the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions.

Trustworthiness

In the study, insight into the nature of the phenomenon was sought regarding the utilization of technical skills, human skills, and conceptual skills in leadership positions by engineering leaders. The three sources of data were the demographic information questionnaire, the Northouse Skills Inventory Surveys (2018), and in-depth interviews with engineering leaders. Based on the qualitative descriptive design of the study, it is important to establish trustworthiness.

Trustworthiness is the ability to demonstrate the quality of data in the study (Bradshaw et al., 2017). According to Bradshaw et al. (2017), Lincoln and Guba created the criteria for trustworthiness in 1985 which can be applied to qualitative descriptive designs. Criteria for establishing trustworthiness in a qualitative descriptive design includes credibility, confirmability, dependability, and transferability (Bradshaw et al., 2017). Also, Yin (2016) noted the importance of incorporating trustworthiness in the methods used to capture the data within the study. Based on the concepts discussed by Bradshaw et al. (2017) and Yin (2016), the researcher provided details on how the study was designed to establish trustworthiness.

To enhance trustworthiness, potential bias was reduced by providing a specific approach to data collection. Yin (2016) stressed the importance of identifying the site of the study, the type of participants, and the steps for collecting the data to improve trustworthiness of the study. Yin (2016) also suggested that bias can be reduced and trustworthiness can be increased by including accurate descriptions from participants. Direct quotes from the participants are included in the results and findings of the study.

Credibility. Yin (2016) suggested credibility is achieved by showing that the data was properly collected and interpreted to ensure the findings reflect the information gathered from the participants in the study. Colorafi and Evans (2016) defined credibility as ensuring the truth in the data and suggested approaches to help researchers, such as using multiple sources of data and showing the link to the theoretical foundation.

To establish credibility throughout the study, the researcher followed the criteria for qualitative methodologies suggested by Colorafi and Evans (2016) and Bradshaw et al. (2017). For example, the researcher obtained data through multiple sources by utilizing the Northouse Skills Inventory Surveys (2018) and in-depth interviews. Both surveys and in-depth interviews were based on the theoretical foundation of Katz three skills model (1955) which included the utilization of technical skills, human skills, and conceptual skills.

In addition to multiple data sources and the theoretical foundation, member checking was done during and after the interview process. Bradshaw et al. (2017) suggested using member checking to ensure the data collected matches the descriptions from the participants. During the interview process, the researcher asked follow-up questions and clarifying questions based on the participant's answers. After the interviews were completed, individual interview transcripts were sent to each participant to verify the accuracy of the data.

Confirmability. Similar to credibility, confirmability is another factor that can help establish the trustworthiness of the study. The concept of confirmability includes the ability of the researcher to show neutrality and no bias in the study (Colorafi & Evans, 2016). To demonstrate confirmability in qualitative descriptive research, Bradshaw et al. (2017) recommended keeping an audit trail of the data collection and analysis process, including direct quotes from participants in the results and findings, and utilizing member checking to validate the data captured in the in-depth interviews.

For the study, guidance from Bradshaw et al. (2017) was used during the data collection and analysis process in the study by creating an audit trail, including direct quotes in the results and findings, and performing member checking. The details of data collection and analysis procedures will be described in subsequent sections of this methodology chapter.

Dependability. Moon, Brewer, Januchowski-Hartley, Adams, and Blackman (2016) defined dependability as the reliability of the findings and the consistency of the research procedures. Colorafi and Evans (2016) noted that dependability can be achieved by ensuring consistency throughout the research process. For example, prior to the interview process, interview questions were developed based on the theoretical foundation of Katz (1955) skills model and information from prior research studies completed by Boyatzis et al. (2017), Kalliamvakou et al. (2017), Medcof (2017), Racine (2015), and Rottmann et al. (2016). During the interview process, the researcher was the instrument and asked the same questions in the same order to ensure consistency in data collection.

Based on the use of in-depth interviews with the researcher as the instrument in the study, there may be a threat to the dependability of the findings due to potential personal bias. Moon et al. (2016) suggested using reflexivity to increase transparency in the research process and reduce bias. Reflexivity is defined as the interplay between study participants and the researcher, where the participants may be influenced by the actions of the researcher (Yin, 2016). The researcher was cognizant of reflexivity during the study through self-reflection and monitoring for personal bias during the interview process.

Transferability. The final criteria used to establish trustworthiness in the study was the consideration of transferability. Colorafi and Evans (2016) explained that transferability is how a study may be applicable in other settings or studies. To establish transferability, the researcher can use tactics such as purposive sampling and providing a detailed data collection process in the study (Bradshaw et al., 2017). Purposive sampling was used in the study based on the need for rich and relevant information from participants to answer the research questions (Yin, 2016). The sample in the study consisted of 23 engineering leaders for the Northouse Skills Inventory Surveys (2018) and 14 engineering leaders for the interviews, all of whom were in the information technology field in the United States who had more than two years of leadership experience within the engineering discipline and were part of the LinkedIn network of engineering leaders, to which the researcher also belonged. LinkedIn has members world-wide but only those residing in the United States who had a connection to the researcher's LinkedIn account were included in the sample. In addition to purposive sampling, the researcher provided detailed steps for data collection to allow for replication in other studies.

Data Collection and Management

In this qualitative descriptive study to explore how engineering leaders described the utilization of technical skills, human skills, and conceptual skills in their leadership positions, data was collected via the Northouse Skills Inventory Surveys (2018) and in-depth interviews. The researcher requested and received the GCU Institutional Review Board (IRB) approval before starting the study. Once the researcher obtained GCU IRB approval, the participants were contacted and agreed to participate in the study via the informed consent form. The process for gathering the data from participants is described below. Once the data was captured, the researcher followed GCU IRB's guidelines for securing and maintaining the data.

The following steps were used in the study for the data collection process:

1. The researcher requested and received GCU IRB approval to start data collection for the study.

2. Passively recruited participants who were a part of the researcher's LinkedIn network in the United States based on their work experience in engineering leadership. The types of leaders who were considered as participants were middle and top engineering leaders who had more than two years of leadership experience within the engineering discipline in the information technology field.

3. Purposive sampling was used to send recruitment emails to 80 participants in the target population to request their participation via the a LinkedIn message that

included the purpose of the study, information about the study, and the link to SurveyMonkey which included the informed consent form, demographic information, and the Northouse Skills Inventory Survey (2018), in that unalterable sequence.

4. Obtained consent, demographic information, and the Northouse Skills Inventory Survey (2018) data from 23 engineering leaders within the information technology field who had more than two years of leadership experience in the engineering discipline. The researcher followed up four times (every two weeks) to reach out to participants who did not immediately respond to the recruitment email.

5. Saved information gathered on Northouse Skills Inventory Surveys (2018) on a personal computer with password protection.

6. After each participant completed the Northouse Skills Inventory Survey (2018), the researcher contacted the participant and scheduled an individual meeting to conduct the in-depth interview. The interviews were scheduled as soon as the participant completed the Northouse Skills Inventory Survey (2018).

7. The interviews included 14 participants who were interviewed via phone/video conference for a minimum of 30 minutes, using a recording device. The researcher utilized an inquiry-based conversation as suggested by Castillo-Montoya (2016), to obtain details about the participants' experiences by asking one question at a time, not interrupting, asking clarifying questions, and communicating follow up procedures at the end of the interview. Boyce and Neale (2006) indicated bias can be a factor during the interview process and suggested creating an interview protocol prior to conducting interviews. An interview protocol was constructed for this study (see Appendix F) with an introduction, general questions, and open-ended semi-structured interview questions, and next steps.

8. Bias was diminished in the follow-up questions by using reflexivity, respondent validation, and member checking. Birt et al. (2016) suggested that novice researchers use techniques such as actively engaging the participants to confirm the information was captured accurately by the researcher. In addition to engaging participants through validation and member checking, Moon et al. (2016) suggested researchers can do a self-assessment during the interview to monitor subjectivity and reduce personal bias via reflexivity.

9. Castillo-Montoya (2016) suggested researchers be prepared with a few follow-up questions to help clarify participant responses. For example, if the researcher wanted to know more about the initial question: How do you feel about the way you relate to your subordinates? A follow-up question could be: How have your feelings about relationships with subordinates changed as your leadership experience has increased? Another example of a follow up question could be based on the initial interview question: How important is self-regulation in your

leadership position? A follow-up question could be: What is an example of a time when you had to practice self-regulation in your leadership position?

10. Data from the Northouse Skills Inventory Surveys (2018) were stored in SurveyMonkey. Once the surveys were complete, participant names were removed and aggregate data such as mean and standard deviation were calculated for the responses to each survey question.

11. Data from the interviews was prepared for analysis by transcribing the audio/video files into data files, completing member checking with participants and de-identifying the participants' names to maintain confidentiality, before importing into MAXQDA.

12. Data will be maintained in a locked safe for three years per GCU IRB guidelines. After three years, if the data is deemed no longer needed, the researcher will destroy the data.

Throughout the data collection process, the rights and well-being of the participants were protected through confidentiality and credibility. Bradshaw et al. (2017) pointed out how credibility can be achieved with participants by establishing rapport before starting the interview. Confidentiality was maintained by ensuring the names of the participants and the name of the organizations were not included in the study. The data captured via the Northouse Skills Inventory Surveys (2018) and in-depth interviews were used to address the research questions regarding how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions. In the next section, the data analysis procedures for the study will be addressed.

Data Analysis Procedures

The problem that was addressed in this qualitative descriptive study was: it was not known how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions. Based on this problem, three research questions were created and guided the data collection and analysis in the study:

RQ1: How do engineering leaders describe the utilization of technical skills in their leadership positions?

RQ2: How do engineering leaders describe the utilization of human skills in their leadership positions?

RQ3: How do engineering leaders describe the utilization of conceptual skills in their leadership positions?

Two of the three data sources were used to collect information to answer the research questions: the Northouse Skills Inventory Survey (2018) and individual interviews. Twenty-three participants in the study completed the Northouse Skills Inventory Survey (2018) and 14 participated in in-depth interviews. Both data sources were based on the theoretical foundation of the Katz (1955) skills model. Data collected from both sources was analyzed to answer the three research questions. Data was prepared for analysis based on the close-ended responses from the Northouse Skills Inventory Surveys (2018) and open-ended responses from the in-depth interviews.

Analysis of close-ended responses. Data preparation for the Northouse Skills Inventory Surveys (2018) followed a different process than what was used for the interview data. The individual participant's scores from the Northouse Skills Inventory Survey (2018) were calculated for each of the areas of the survey (technical skills, human skills, and conceptual skills) to align with each research question. The individual participant's results showed how each participant scored and will be used in the results section. For example, adding together the scores for statements 1, 4, 7, 10, 13, 16 created a total score for Technical Skills; statements 2, 5, 8, 11, 14, 17 generated a total score for Human Skills; and statements 3, 6, 9, 12, 15, 18 generated a total score for Conceptual

Skills (see Appendix M). Aggregate data such as frequency counts, mean values, and standard deviation were computed based on the responses for each statement in the Northouse Skills Inventory Survey (2018) (see Appendix L) and will be used in the results section to provide an initial view into how engineering leaders utilize technical skills, human skills, and conceptual skills in their leadership positions.

Analysis of open-ended responses. Data preparation for open-ended responses included transcribing the data from the in-depth interviews into a text format based on the recording captured during the interview. A transcription service was used to convert the recorded interviews into MSWord documents. After receiving the transcripts, the researcher reviewed and cleaned up the data to ensure accuracy by re-listening to the audio recordings and comparing to the written transcripts. Researchers are encouraged to check interview data to validate the information captured (Birt et al., 2016). Qualitative analysis is an iterative process (Colorafi & Evans, 2016), thus the researcher followed up with participants via member checking by emailing a copy of the transcripts to individual participants for review. The transcripts were updated based on feedback from the participants.

As part of the data analysis process, MAXQDA was employed as a tool for organizing the results of the in-depth interviews. MAXQDA is a tool used in qualitative data analysis to help researchers keep track of codes, sub-themes, and themes when analyzing data such as interview transcripts. Oliveira, Bitencourt, Zanardo dos Santos, and Teixeira (2016) noted the benefit of MAXQDA software as a valuable tool for qualitative studies based on the ease of use in coding and presenting results.

To ensure robust data analysis and reduction of potential bias, a thematic analysis process was used to analyze the open-ended questions, which consisted of "identifying, analyzing, and reporting patterns (themes) within data" (Braun & Clarke, 2006, p. 6). Thematic analysis is a widely used qualitative data analysis procedure with clear guidelines to help the researcher identify patterns that emerge in the data (Braun & Clarke, 2006). Castleberry and Nolen (2018) noted the value of using thematic analysis in qualitative studies as a respected data analysis technique which involves compiling, disassembling, reassembling, interpreting, and concluding the data. The following six steps described by Braun and Clarke (2006) were used in the data analysis. The researcher used the following phases of thematic analysis proposed by Braun and Clarke (2006) to analyze the data from the in-depth interviews:

1. ***Becoming familiar with the data***. The researcher became familiar with the data through immergence by re-reading the transcripts and making initial notes on what was reported.

2. ***Generating initial codes***. Once the researcher loaded the data into MAXQDA, the data was analyzed to identify codes. Coding is a way to organize the data into meaningful groups (Braun & Clarke, 2006).

3. ***Searching for themes***. After the coding was complete, the researcher analyzed the codes to identify sub-themes and themes.

4. ***Reviewing the themes***. Once the themes were identified, the researcher re-reviewed the sub-themes to ensure they fit the themes and answered the research questions. Braun and Clarke (2006) suggested a two-step process to review the themes which included the validation that the sub-themes fit into the themes and also fit into the entire data set. Thus, the researcher reviewed the sub-themes and themes based on the interview transcripts across all the participants.

5. ***Defining and naming themes***. Once the researcher reviewed the themes, each theme was defined and named in relation to the research questions. Braun and Clarke (2006) suggested writing a detailed analysis of each theme that describes the data to answer the research questions.

6. ***Produce a report***. The results of the data analysis are presented in Chapter 4 of the study.

The quantity and quality of the data was sufficient to answer the research questions based on the number of respondents to the interviews and the length of the transcripts of interview data. GCU guidelines indicated that descriptive studies have a minimum of 10 participants and no less than five pages of single spaced, Times New Roman 12-point font should be generated per interview (Grand Canyon University, 2017). There were 14 interviews within this study with a minimum of nine pages and a maximum of 21 pages. The researcher determined data saturation had been achieved after the 12th interview when data started to become repetitive and no new data emerged.

Ethical Considerations

Guidelines from the Belmont Report (Department of Health, 2014) and the GCU IRB were incorporated to ensure ethical behavior in the study. When conducting a study on human participants, the Belmont Report (Department of Health, 2014) suggested researchers take into account the ethical considerations of respect for persons, beneficence, and justice. The population of interest was all engineering leaders within the information technology field in the United States. The target population was all middle and top-level engineering leaders within the information technology field in the United States who have more than two years of leadership experience within the engineering discipline and were connected to the researcher's LinkedIn network. The sample consisted of 23 engineering leaders for the Northouse Skills Inventory Surveys (2018) and 14 engineering leaders for the interviews, all of whom were in the information technology field in the United States, have more than two years of leadership experience within the engineering discipline, and were connected to the researcher's LinkedIn network. The sample had more than two years of experience in leadership positions within the information technology field and reside in the United States.

Regarding the respect for persons, the Belmont Report (Department of Health, 2014) identified two considerations: participants are treated as autonomous agents and are entitled to protection. Based on these guidelines of both the Belmont Report (Department of Health, 2014) and the GCU IRB, informed consent was obtained from each participant before continuing to the Northouse Skills Inventory Surveys (2018) and conducting in-depth interviews. The informed consent form is available in Appendix C. The purpose of the study and the confidentiality measures taken in the study were explained to participants before starting the data collection process.

The Belmont Report (Department of Health, 2014) identified benevolence as having respect for participant’s wellbeing and respecting their decisions. With this in mind, participants were informed they can leave the study at any time without any ramifications. The data collection initially included the names of engineering leaders participating in the study, but after the data collection was complete, the names of the participants were removed to preserve the privacy of the individuals. In place of the names of participants, identifiers were used to keep track of the data during analysis.

To address the guidelines for justice, which includes participants being treated equally, the same data gathering process (as defined in the Data Collection and Management section) was followed to ensure consistency during interactions with participants. After data collection was complete, the individual transcripts were provided to each participant for member checking to validate the information gathered. There were no problems in the data collection process because the nature of the study was not controversial or emotional for the participants.

GCU IRB procedures were followed for data management after the study. For example, the researcher will keep all paper materials in a locked safe and all electronic materials in a password-secured personal computer for a minimum of three years. After three years, if the information is no longer required, the paper materials will be destroyed via a shredder and delete the electronic materials from the personal computer.

Limitations and Delimitations

As discussed in Chapter 1, there were potential limitations and delimitations to the study. Ellis and Levy (2010) noted that limitations are situations which are unavoidable when conducting a study but can be mitigated by establishing the reliability of the methods used during the study. Two limitations were identified in the first chapter. The first limitation was the potential limited time of engineering leaders due to busy schedules. The second limitation was the potential for prior contact between the researcher and participants due to the researcher being a member of the professional networking website, LinkedIn. In addition to the limitations discussed in Chapter 1, additional limitations exist such as the limits and potential for personal bias associated with qualitative studies, semi-structured interviews, and data analysis. The process of capturing limitations and delimitations was continued throughout the data collection and analysis phases of the study, and the researcher updated the list after the data collection/analysis was complete.

Limitations. Qualitative studies may be subject to bias due to the researcher being part of the instrument and involved in data analysis (Yin, 2016). Some of the limitations that could introduce bias may include interactions with the participants during the interview and interaction with the data during the data analysis. The research procedures were described to the participants. As mentioned by Moon et al. (2016), the reliability of the findings and the consistency of the research procedures can be established by following accepted processes and established tools. Thus, the researcher explained the data collection/analysis procedures and tools to show participants the validity of the study. By establishing validity, the researcher may gain more buy-in and time commitment from the participants because the results of the study may be useful in improving engineering leadership within their organizations.

In addition to interactions with participants during the interview, it was important to be conscious of potential personal bias throughout the interview and analysis process. Yin (2016) described personal bias as a limitation in qualitative methods due to the risk of viewing the research through a particular research lens. In other words, the research lens is the viewpoint of the researcher based on the participants attributes, the researcher's prior experiences, and the researcher's cultural orientation (Yin, 2016). To overcome this limitation, the researcher practiced reflexivity during the interview process by asking open-ended questions and adhering to the interview protocol. To address the limitation of potential bias during data analysis, the researcher removed participants names from the data. In addition to removing participant information, a thematic analysis process was utilized to analyze the data. Braun and Clarke (2006) suggested a six-step processes of thematic analysis to systematically analyze qualitative data to reduce bias.

Another limitation identified by the researcher was the potential prior connections with some of the participants because the researcher has a LinkedIn account. Since the target population of the study includes middle and top-level engineering leaders within the information technology field and have a connection with the researcher on LinkedIn, there was a chance the researcher may have had past connections with the participants. If a participant had a past relationship with the researcher based on being in the information technology field or having the connection on LinkedIn, the potential relationship may influence the responses during the interview, such as not receiving honest answers to questions, and after the interview during data analysis. To help overcome this potential limitation, the anonymity and confidentiality of the data were reiterated before starting the interview and the participants knew they could decline to participate in the interview.

During the interview process, the researcher used reflexivity through self-reflection to monitor for personal bias. Yin (2016) noted how reflexivity is the relationship between the participant and the interviewer, where the participant may be swayed by actions from the interviewer. Thus, being aware of the interaction with participants helped the researcher reduce bias and mitigate the limitation of the researcher being part of the instrument. After the interview, during data analysis, the researcher removed participants names before starting the coding process to reduce personal bias and minimize the impact on the results of the study.

One of the limitations discussed previously was the acknowledgment that engineering leaders have numerous responsibilities during the workday. Thus, taking time out of their schedule to complete the Northouse Skills Inventory Survey (2018), participate in an in-depth interview, and complete member checking after the interview has been completed may be challenging. The consequence of this limitation may be a longer duration for data collection than anticipated. To mitigate this limitation, the researcher proactively discussed the timeframes needed from the participants before starting data collection and provided an incentive for participating in the study. The researcher started with a sample of 14 participants for the interviews but did not need to tap into the reserve because saturation was reached and there was no attrition.

Delimitations. In addition to limitations, the researcher identified the delimitations of the study. Delimitations are limitations imposed by the researcher to set boundaries for the proposed study (Ellis & Levy, 2010). One delimitation identified in Chapter 1 was the purposive sampling of 23 engineering leaders for the Northouse Skills Inventory Surveys (2018) and 14 engineering leaders for the interviews, all of whom were connected to the researcher's LinkedIn network, and reside in the United States. Purposive sampling is important in qualitative designs because the researcher is studying a small sample of participants to gain a detailed understanding of the phenomenon (Yilmaz, 2013). Based on the qualitative descriptive design of the study, a large sample size would have been prohibitive to complete an in-depth study of the phenomenon.

Additional delimitations identified in Chapter 1 were the timeframe of the data collection and the use of qualitative descriptive design. The timeframe was delimited to two months to complete the study in a reasonable timeframe. A qualitative descriptive design was chosen because of interest in the descriptions of engineering leaders in what Lambert and Lambert (2012) explained as a natural state. The focus of the study was not to establish a theory through a grounded theory approach, a case study as exploring a bounded system and its internal factors, or a phenomenology that focuses on understanding participants' consciousness (Bradshaw et al., 2017). Thus, a delimitation of a qualitative descriptive design was appropriate for the study.

Summary

The purpose of this qualitative descriptive study was to explore how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions within the information technology field in the United States. Based on the continued increase in the dependency on technology within organizations, there is an ongoing need to develop engineering leaders (Broy, 2018). The study may provide guidance on the skills needed to develop future engineering leaders. In addition to the potential benefit to organizations, the study provided additional insights into the discrepancies among existing literature, such as the utilization of technical skills in engineering leadership positions (Kalliamvakou et al., 2017; Rottmann et al., 2016) and the lack of research on conceptual skills in engineering leadership (Medcof, 2017).

The following research questions were created for the study based on the theoretical foundation of Katz's (1955) three skills model and set out to address the phenomenon of the utilization of technical skills, human skills, and conceptual skills in leadership positions by engineering leaders:

RQ1: How do engineering leaders describe the utilization of technical skills in their leadership positions?

RQ2: How do engineering leaders describe the utilization of human skills in their leadership positions?

RQ3: How do engineering leaders describe the utilization of conceptual skills in their leadership positions?

A qualitative methodology was used for the study due to the inductive nature of the phenomenon. Yilmaz (2013) suggested using a qualitative methodology to explore participants experiences. A descriptive design was used to explore the real-world experiences of engineering leaders. Qualitative descriptive designs capture a phenomenon in everyday terms and provide rich information to the organization which can be used to improve leadership development (Merriam & Tisdell, 2016; Sandelowski, 2000). Two of the three data sources were utilized for the data collection to answer the research questions: Northouse Skills Inventory Survey (2018) and in-depth interviews. The Northouse's (2018) skills inventory captured the utilization of technical, human, and conceptual skills used in leadership positions. The in-depth interview questions were based on Katz's (1955) three skills model and prior engineering leadership studies (Boyatzis et al., 2017; Kalliamvakou et al., 2017; Medcof, 2017; Racine, 2015; Rottmann et al., 2016).

The general population for the study was all engineering leaders within the information technology field in the United States. The target population was all middle and top-level engineering leaders within the information technology field in the United States who have more than two years of leadership experience within the engineering discipline and were connected to the researcher's LinkedIn network of engineering leaders. The sample drawn from the target population consisted of 23 engineering leaders for the Northouse Skills Inventory Surveys (2018) and 14 engineering leaders for the interviews. The setting for the proposed study was the social media professional networking website, LinkedIn, where the researcher had connections to 80 engineering leaders in the United States. These 80 potential participants were recruited for the Northouse Skills Inventory Survey (2018) and the interview via purposive sampling. LinkedIn has members world-wide but only those residing in the United States who had a connection with the researcher's LinkedIn account were included in the study. The researcher chose purposive sampling based on the assertions from Yin (2016) and Etikan et al. (2016) regarding the value of participants having specific knowledge related to the research questions.

The researcher ensured the trustworthiness of the study through the use of qualitative design methods and by following the criteria for qualitative descriptive designs which includes credibility, confirmability, dependability, and transferability (Bradshaw et al., 2017; Yin, 2016). The researcher ensured credibility by using multiple data sources and basing the Northouse Skills Inventory Surveys (2018) and in-depth interview questions on the theoretical foundation of Katz's (1955) three skills model. Credibility can be established through the use of multiple data sources and connection to a theoretical foundation (Colorafi & Evans, 2016).

Confirmability can be established by the researcher showing neutrality and lack of bias (Colorafi & Evans, 2016), Thus, the researcher utilized processes such an audit trail for data collection and analysis, member checking, and using direct quotes in the findings. In qualitative studies, with the researcher as the instrument, the researcher must show consistency throughout the research study. Colorafi and Evans (2016) considered the concept of consistency to be a part of dependability, which can lead to trustworthiness. Hence, the researcher followed the same process for data collection with every participant. Finally, as part of trustworthiness, the researcher needs to show transferability. In other words, how the study may be applicable in other settings or studies (Colorafi & Evans, 2016).

The data collection process was a collection of Northouse Skills Inventory Surveys (2018) and in-depth interviews. GCU IRB approval was obtained before starting the study. Passive recruiting was used as the recruitment strategy. Purposive sampling was used to select the participants, who agreed to participate in the study via the informed consent form before participating in the Northouse Skills Inventory Survey (2018) and in-depth interviews. The Northouse Skills Inventory Survey (2018) included 23 engineering leaders and interviews included 14 engineering leaders with more than two years of leadership experience in the information technology field. The Northouse Skills Inventory Survey (2018) data was prepared by removing participants names and generating frequency, mean, and standard deviation scores for each survey response. Interview data was prepared and imported into MAXQDA for analysis. Thematic analysis is used in qualitative research to identify, analyze, and report themes based on the data (Braun & Clarke, 2006). The thematic analysis procedure suggested by Braun and Clarke (2006) was used to analyze the in-depth interviews.

Identifying the ethical limitations of the study ensures the researcher considers the ethical aspects of the study. The researcher used the Belmont Report (Department of Health, 2014) and the GCU IRB as guidelines for the study. This included considerations such as respect for persons, beneficence, and justice as noted in the Belmont Report

(Department of Health, 2014). The researcher addressed respect for persons via informed consent from participants before starting the data collection process. The participants had the ability to leave the study at any time and the participants who completed the study will not have their names included to show respect for privacy, which is described as benevolence in the Belmont Report (Department of Health, 2014). Justice indicates that participants will be treated fairly, thus the researcher ensured consistency when interacting with participants throughout the study (Department of Health, 2014).

In the final section of Chapter 3, the researcher addressed limitations and delimitations. Limitations are situations which are unavoidable for the researcher (Ellis & Levy, 2010). The researcher identified the potential time limitations of engineering leaders due to busy work schedules and discussed timeframes with participants before starting the data collection. In addition to time limitations of the participants, a limitation based on personal bias due to the researcher as the instrument was discussed. Mitigations were provided such as reflexivity, following interview protocols, and removal of demographic information (Yin, 2016). Delimitations are limitations that are established by the researcher (Ellis & Levy, 2010). The researcher utilized purposive sampling with 23 engineering leaders for the Northouse Skills Inventory Survey (2018) and 14 engineering leaders for the interviews to gain an understanding of the phenomenon based on the leader's real-world experiences. Using a large sample size was prohibitive in achieving an in-depth study of the phenomenon.

In the next chapter, the researcher will present the data analysis and the results of the study. Chapter 4 will have an introduction to the section, provide a summary of the descriptive findings, show the detailed data analysis procedures used during the study, and present the results of the study. Chapter 5 is a summary of the study and the findings, as well as the implication of the study, and recommendations for future research.

Chapter 4: Data Analysis and Results

Introduction

The purpose of this qualitative descriptive study was to explore how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions within the information technology field in the United States. The sample included 23 software engineering leaders for the Northouse Skills Inventory Survey (2018) and 14 software engineering leaders for the interviews. All of the software engineering leaders had at least two years of leadership experience in the information technology field. As organizations continue to increase the use of technology, the demand for leaders within the information technology field continues to increase (Gallipoli & Makridis, 2018). Thus, understanding the skills utilized by software engineering leaders is needed to prepare upcoming leaders within the information technology field.

The research questions stemmed from the problem statement: it was not known how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions. The research questions were based Katz's (1955) three skills model which identified three types of skills: technical skills (proficiency at a specific task), human skills (capability to focus on people), and conceptual skills (ability to see the whole organization) used by leaders. The overarching research question was: How do engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions? The following research questions guided the qualitative descriptive study:

RQ1: How do engineering leaders describe the utilization of technical skills in their leadership positions?

RQ2: How do engineering leaders describe the utilization of human skills in their leadership positions?

RQ3: How do engineering leaders describe the utilization of conceptual skills in their leadership positions?

Two of the three sources of data were used to address the research questions: the Northouse Skills Inventory Survey (2018) and in-depth interviews. The first data source was a survey created by Northouse (2018) to capture the software engineering leaders' perceptions of the utilization of technical, human, and conceptual skills. The Skills Inventory Survey (Northouse, 2018) consisted of 18 statements designed to provide a high-level summary of the skills utilized in leadership roles based on Katz' (1955) three skills for effective leadership (technical, human, and conceptual skills). The second data source consisted of in-depth interviews to elicit descriptions of the software engineering leaders' skillset based Katz (1955) theory on the utilization of technical, human, and conceptual skills. Sandelowski (2000) indicated the value in using a qualitative descriptive design to capture perceptions from participants in a natural state. In-depth interviews were used to capture the descriptions of the phenomenon in everyday terms.

The purpose of Chapter 4 was to provide a summary of the data, including the analysis and results of the research study. This chapter contains explanations of how descriptive data was computed for the scores from the Northouse Skills Inventory Survey (2018) and how the interview data was analyzed using thematic analysis. This chapter also includes the results of the data analysis and a summary of the chapter.

Descriptive Findings

Software engineering leaders were recruited from the social media professional networking website, LinkedIn, for this qualitative descriptive study. The researcher had connections to 80 software engineering leaders who could potentially participate in the study. Purposive sampling was used to recruit the software engineering leaders based on the criteria of having more than two years of leadership experience in the information technology field and residing in the United States. Yin (2016) suggested purposive sampling as a way to select participants based on the richness of answers to the research questions. Out of the 500+ connections in the researcher's LinkedIn account, 80 people were identified as engineering leaders based on their job titles. Out of the 80 recruitment letters sent via LinkedIn's Messaging feature; 35 software engineering leaders responded. Ten of the 35 replied via LinkedIn Messenger to inform the researcher that they could not participate in the study due to lack of time, not residing in the United States, not being in an engineering leadership position, not having more than two years in engineering leadership, or no longer being employed.

Twenty-five software engineering leaders responded to the recruitment letter by accessing the study documents via SurveyMonkey. Two of the 25 potential participants opted out of the SurveyMonkey survey at Question 1, pertaining to the informed consent document, which asked participants to select *Consent* to agree to participate in the study or *Opt Out* to leave the study. Twenty-three participants became part of the sample by agreeing to the informed consent within the SurveyMonkey link, continued to the demographic information questionnaire, and completed the Northouse Skills Inventory Survey (2018).

After each Northouse Skills Inventory Survey (2018) was completed, the researcher contacted the participants to schedule in-depth interviews. The researcher intended to continue with in-depth interviews until the point of saturation. Mason (2010) explained that the researcher could start seeing repetitive information which may indicate saturation and diminished returns with additional participants. After the 12th interview, the researcher started noticing repetitive information, but continued with two additional interviews to ensure saturation. The final two interviews confirmed that no new information was surfacing, thus the researcher stopped reaching out to the additional participants who had completed the Northouse Skills Inventory Survey (2018). Overall, the researcher ended up with 14 in-depth interviews from the pool of 23 participants who completed the Northouse Skills Inventory Survey (2018).

Demographic information questionnaire. The 23 software engineering leaders who decided to participate in the study completed a demographic information questionnaire before starting the Northouse Skills Inventory Survey (2018). The demographic information questions asked the participants to identify their current title, the length of time in a leadership role within the engineering industry, confirmation that they reside in the United States, and confirmation that they had a LinkedIn account. Based on the results of the demographic information questions, one software engineering leader had three to five years of engineering leadership experience, two had six to eight years of engineering leadership experience, three had nine to eleven years of engineering leadership experience, two had 12 to 14 years of engineering leadership experience, and 15 had over 15 years of engineering leadership experience. The participants also identified their current titles, which consisted of one manager, five senior managers, six directors, four senior directors, six vice presidents, and one that fell into the “other” category and self-identified as a Chief Technology Officer (CTO). Beckhusen (2016) identified the role of CTO as an occupation that plans, directs, and coordinates activities within the information technology field in an organization. All 23 of the participants answered “yes” to the questions about residing in the United States and having a LinkedIn account. Demographic results are presented in Table 1.

Table 1.

Demographics of Northouse Skills Inventory Survey (2018)

Software Engineering Leaders	Title	Length of Time in Leadership Role	Resides in the United States	Has LinkedIn Account
Participant 1	Director	15+ years	Yes	Yes
Participant 2	Manager	6-8 years	Yes	Yes
Participant 3	Senior Director	15+ years	Yes	Yes
Participant 4	Senior Manager	6-8 years	Yes	Yes
Participant 5	Vice President	15+ years	Yes	Yes
Participant 6	Senior Manager	15+ years	Yes	Yes
Participant 7	Director	15+ years	Yes	Yes
Participant 8	Director	12-14 years	Yes	Yes
Participant 9	Director	15+ years	Yes	Yes
Participant 10	Director	9-11 years	Yes	Yes
Participant 11	Director	9-11 years	Yes	Yes
Participant 12	Senior Director	15+ years	Yes	Yes
Participant 13	Senior Director	15+ years	Yes	Yes
Participant 14	Senior Manager	3-5 years	Yes	Yes
Participant 15	Vice President	15+ years	Yes	Yes
Participant 16	CTO	12-14 years	Yes	Yes
Participant 17	Senior Manager	15+ years	Yes	Yes
Participant 18	Senior Manager	15+ years	Yes	Yes
Participant 19	Vice President	9-11 years	Yes	Yes
Participant 20	Vice President	15+ years	Yes	Yes
Participant 21	Senior Director	15+ years	Yes	Yes
Participant 22	Vice President	15+ years	Yes	Yes
Participant 23	Vice President	15+ years	Yes	Yes

The participants in the study were from different organizations but had similar titles. Medcof (2017) described the difference in managerial levels based on titles such as top (executive), middle management, and bottom (supervisory). The titles identified within the demographics information relate to two of these levels – top and middle management. For example, CTO and Vice President related to top (executive) managerial levels compared to the rest of the titles which fell into the middle management level. There were no bottom (supervisory) levels included in the study because according to Medcof (2017), top and middle level engineering leaders have more experience in leadership and could provide more information on the utilization of leadership skills.

Survey data. The survey used in this research study was the Northouse Skills Inventory Survey (2018) based on Katz's (1955) theory of three skills used by effective leaders: technical skills, human skills, and conceptual skills. The Skills Inventory Survey consisted of 18 statements to address the three research questions. Statements 1, 4, 7, 10, 13, and 16 identified the leader's perceptions of their utilization of technical skills (RQ1). Statements 2, 5, 8, 11, 14, and 17 indicated the leader's perception of their utilization of human skills (RQ2). Statements 3, 6, 9, 12, 15, and 18 revealed the leader's perception of their utilization of conceptual skills (RQ3). The Northouse Skills Inventory Survey (2018) was administered via SurveyMonkey once the participant agreed to the informed consent and completed the demographic information questions. All participants responded to all of the statements in the survey. The purpose of the Northouse Skills Inventory Survey (2018) was to capture an initial view of how software engineering leaders utilized technical, human, and conceptual skills within their leadership positions.

The frequency, mean, and standard deviation data were calculated for each of the Northouse Skills Inventory Survey (2018) questions and used for data analysis (see Appendix L). The individual participant's results show how each participant scored and will be used in the results section. For example, adding together the scores for statements 1, 4, 7, 10, 13, 16 created a total score for Technical Skills; statements 2, 5, 8, 11, 14, 17 generated a total score for Human Skills; and statements 3, 6, 9, 12, 15, 18 generated a total score for Conceptual Skills (see Appendix M). A report of the results of the Northouse Skills Inventory Survey (2018) data can be found in Appendices L and M.

Semi structured interview data. The interviews with 14 of the participants allowed the researcher to take a deeper look into the meanings behind each of the skills identified by Katz (1955) and helped drive an in-depth understanding of the utilization of technical skills, human skills, and conceptual skills by software engineering leaders. The interview questions utilized can be found in Appendix F. The researcher used Zoom meetings and an inquiry-based conversation, as suggested by Castillo-Montoya (2016), to get information from the leaders by providing a context around the topics, asking one set of questions at a time, not interrupting, asking clarifying questions, and communicating next steps at the end of the interview.

All participants expressed enthusiasm and willingness to provide thoughtful and meaningful answers to all of the interview questions. A few of the participants commented about how much they enjoyed the research questions and discussion, indicating they may use these types of questions when interviewing candidates for potential software engineering leadership positions. All of the participants wanted a readout on the findings of the study. The average/mean time for the interviews was approximately 42 minutes.

The interviews were transcribed using a transcription service and reviewed at least twice by the researcher to ensure accuracy. The average length of transcribed data was 14.14 pages. A list of individual participants' amount of time and number of transcription pages can be seen in Table 2.

Table 2.

Individual Interview Data for each Software Engineering Leader

Software Engineering Leader	Date of Interviews	Length of Interviews (in Minutes)	Pages of Single-Spaced Interview Data Transcribed
Participant 1	2/13/2020	40	13 pages
Participant 2	3/2/2020	52:20	12 pages
Participant 3	2/17/2020	38:59	16 pages
Participant 4	2/13/2020	38:07	18 pages
Participant 5	2/7/2020	66:48	18 pages
Participant 6	2/21/2020	56	14 pages
Participant 7	2/25/2020	42:59	13 pages
Participant 8	2/25/2020	33:10	14 pages
Participant 9	2/20/2020	42:21	19 pages
Participant 10	2/13/2020	39:01	21 pages
Participant 11	2/6/2020	28:26	11 pages
Participant 12	2/26/2020	35:07	9 pages
Participant 13	2/27/2020	34:45	9 pages
Participant 14	2/27/2020	43:17	11 pages
AVERAGE (MEAN)		42:09	14.14 pages
TOTAL		589:20	198 pages

Once the researcher reviewed each of the transcripts multiple time for accuracy, the transcripts were sent via email to each participant for member checking, so they could provide clarifications or corrections. In the email to participants, the researcher indicated that the participants did not need to respond if they were in agreement with the transcripts. Two of the participants returned comments/clarifications, which were incorporated into the final versions of the transcripts. Eight of the participants responded that the transcripts looked fine. Four of the participants did not respond by the deadline, indicating they were in agreement with the data. The researcher double-checked the email addresses that had been used to communicate with these four participants to make sure it was correct to believe they received the email.

Data Analysis Procedures

The data analysis for the study followed the processes described in the Data Analysis section of Chapter three. The data gathered via the Northouse Skills Inventory Survey (2018) was analyzed by calculating individual participant's scores for each area of the survey (technical, human, and conceptual), as well as mean and standard deviation for each survey statement. When the researcher exported the data from SurveyMonkey, the names of the participants were changed to identifiers (such as Participant 1, Participant 2, etc.) to provide anonymity to the results. The individual participant's scores were calculated based on the three areas of the survey and aligned to the research questions. For example, technical skills (RQ1) was comprised of statements 1, 4, 7, 10, 13, 16; human skills (RQ2) was comprised of statements 2, 5, 8, 11, 14, 17; conceptual skills (RQ3) was comprised of statements 3, 6, 9, 12, 15, 18 (see Appendix M). In addition to the individual participant's scores, each response was analyzed by calculating basic descriptive statistics such as frequency counts, mean values, and standard deviation (see Appendix L).

The next step of the data analysis was the analysis of the in-depth interviews using a thematic analysis approach, which Braun and Clarke (2006) suggested to find patterns in the data. The researcher used the following phases of thematic analysis as suggested by Braun and Clarke (2006) to analyze the interview data. The following list contains the steps taken by the researcher when analyzing the data. Details of each step are provided in the subsequent paragraphs.

1. ***Becoming familiar with the data***. The researcher became familiar with the data through immergence by re-reading the transcripts and making initial notes on the data.

2. ***Generating initial codes***. Once the researcher loaded the data into MAXQDA, the data was analyzed to identify codes. Coding is a way to organize the data into meaningful groups (Braun & Clarke, 2006).

3. ***Searching for themes***. After the coding was complete, the researcher analyzed the codes and created sub-themes of codes before creating the overarching themes.

4. ***Reviewing the themes***. Once the sub-themes were identified, the researcher re-reviewed the sub-themes to ensure that they met the patterns within the codes. Once sub-themes were defined, the researcher created themes to answer each research question. Braun and Clarke (2006) suggested a two-step process to review the themes which included the validation that the sub-themes fit into the themes and also fit into the entire data set. For example, during the data analysis the researcher identified sub-themes within the individual interviews and compared with sub-themes that had emerged with other individual's interviews within the data set.

5. ***Defining and naming themes***. Once the researcher reviewed the sub-themes and themes, the overall themes were created in relation to the research questions. Braun and Clarke (2006) suggested writing a detailed analysis of each theme that answers the research questions. Memos were created in MAXDQA for each sub-theme as initial information, which were collapsed into themes to answer the research questions.

6. ***Produce a report***. The results of the data analysis are presented in the next section of this chapter. A codebook was created from the data in MAXQDA which shows the process of creating initial codes, rolling the codes into sub-themes, and identifying themes associated with the research questions: *List of Codes, Sample Quotes, Frequencies; Sub-Themes, Codes, and Analytical Memos; Research Questions, Themes, Sub-Themes* (see Appendix N). Although some researchers refer to the collapsed groupings of codes as categories, they will be referred to as sub-themes (Saldaña, 2015) for purposes of data analysis in this document.

The following section is a detailed description of the six-step process used to analyze the interview data.

Becoming familiar with the data. During the first step, the researcher read each transcript while re-watching the recorded meeting multiple times to get an initial feel for the responses to each interview question. This process allowed the researcher to become more immersed in the data while also checking on the accuracy of the transcription. Next, the researcher transitioned all of the participant's names in the transcription documents to the same identifiers used in the Northouse Skills Inventory Survey (2018) (Participant 1, Participant 2, etc.) and ensured the individual participant's identities were matched up between the Northouse Skills Inventory Survey (2018) and interviews. In other words, Participant 1 in the Northouse Skills Inventory Survey (2018) was the same person as Participant 1 in the in-depth interviews for the first 14 participants who were involved in both the Northouse Skills Inventory Survey (2018) and interviews. Before loading the transcripts into MAXQDA, the transcripts were broken out by Participant and research question. For example, P1-RQ1 for Participant 1-Research Question 1; P1-R2 for Participant 1-Research Question 2, etc. until each participant's transcripts were broken out into specific documents to represent each research question. All of the participant data was stored on the researcher's computer with password protection.

Generating initial codes. The second step started with loading the transcripts into MAXQDA based on the breakout of the transcripts (e.g. P1-RQ1, P1-RQ2, P1-RQ3, P1-RQOverall, P2-RQ1, P2-RQ2, P2-RQ3, P2-RQOverall, etc.) for all 14 participants. Next, the researcher created three high level codes in the MAXDQA Code System based on the research questions: RQ1-Technical Skills, RQ2-Human Skills, RQ3-Conceptual Skills and started reading through the transcripts to apply the initial codes. The researcher used a combination of descriptive and In Vivo coding within MAXQDA. Saldaña (2015) suggested using exact words within the data, also known as In Vivo coding, when making the first pass at creating codes from the data to gain more insight into the meanings from participants. As coding progressed, the researcher started using techniques as suggested by Saldaña (2015) such as grouping similar codes together, using selected codes repeatedly, and creating sub-themes of codes by collapsing similar codes onto an overriding sub-theme.

Example of the coding process. Participants answered questions in the context of the utilization of technical skills, human skills, and conceptual skills within their software engineering leadership positions. An example of the coding process for the first research question regarding technical skills included codes such as *facilitator*, based on responses from Participant 1 such as the following. “I pulled the smart people into a room and just facilitated the conversation and got the brain juices flowing.” “I’m more of a facilitator I guess is the way I would classify it.”

Another similar code that surfaced was *overseeing*, which included phrases such as Participant 2 stating, “less hands-on but more engaging the team and talking through different technical options”. Participant 1 indicated “overseeing the operation”. Participant 4 said, “eventually it became them sailing the boat and [I’m] looking towards the front with a forward view and wearing that lens for them”.

The *facilitator* code and the *overseeing* code (along with others such as *collaboration*, *setting overall direction*, *big picture*, *planning*, *guiding* and *coordinating*) were combined into the code of *guiding and coordinating* that could fit into the same sub-theme (see Table 3). Another example of codes that were identified consisted of *decision making* and *technical decisions*, which had similar phrases such as Participant

14 who said, “I think my background helps me understand what problems the team are facing and understands the different options that they’re proposing and what is probably a good path forward”. Participant 7 said, “I would say that the majority of the time I would leave it to the teams to figure out technical problems” and “I’m using my technical background to help me, but I use that probably the least in terms of true raw…how it’s physically going to work” were combined into one sub-theme.

Table 3.

Examples of Initial Coding

Initial Codes	Raw Interview Data
Facilitator	P1: “I pulled the smart people into a room and just facilitated the conversation and got the brain juiced flowing.” “I’m more of a facilitator I guess is the way I would classify it.”
Overseeing	P1: “overseeing the operation”
	P2: “less hands-on but more engaging the team and talking through different technical options”.
	P4: “eventually it became them sailing the boat and [I’m] looking towards the front with a forward view and wearing that lens for them”.
Collaboration	P2: “it's always collaborating with my technical leads or specialists in those areas.”
	P14: “My team as well as myself, we're frequently involved across the organization in some of these technical decisions, and we frequently have to work with the team to identify what is a good solution for the problem you are seeing.”
Setting Overall Direction	P7: “Really more focusing on the enablement of the people, but also focusing on the strategies we want to impose and why we want to do that.”
	P13: “It's more in setting overall direction than in solving…”
Big Picture	P1: “I think it's very important that you have the ability to quickly ingest all of this information and see the big picture.”
Planning	P5: “You’re applying that technology mindset of, where are the bounded contexts of these different teams? And are the right people in the right places?”

Searching for themes and/or sub-themes. Based on the emerging sub-themes from the analysis of the interviews through the creation of initial codes, the researcher took another pass at the codes and combined them into sub-themes within the transcriptions from all the participants and each of the research questions. Saldaña (2015) recommended reviewing the sub-themes created in MAXDQA and then using the memo feature to make notes to start identifying final themes. Continuing with the example used above, the researcher combined the codes of *guiding and coordinating, and technical decisions* and created a sub-theme called *Setting High Level Technical Direction* (Table 4).

Table 4.

Examples of Sub-Theme

Initial Codes	Final Codes	Sub-Theme
Facilitator, Overseeing, Collaboration, Setting Overall Direction, Big Picture, Planning	Guiding and Coordinating	Setting High Level Technical Direction
Decision Making Technical Decisions	Technical Decisions	

The researcher created the following memo for the sub-theme of *Setting High Level Technical Direction*: Although the leaders agreed that it is good to step away from the day-to-day technical details, it is still important to understand the technology enough to help guide the overall approach and technical/architectural direction. The leader can help drive the vision and meet the objectives of the organization by ensuring the team is going in the right direction. Part of setting the high-level technical direction is being a facilitator to help guide the team by asking questions and generating discussion. Based on the sub-themes within each research question and the analytical memos, the researcher created the overarching themes to answer each research question. The codebook with a listing of the codes, sub-themes, and themes are in Appendix N.

Reviewing the themes and sub-themes. When reviewing the themes and sub-themes, the researcher identified two themes in research question one, two themes for research question two, and two themes for research question three. These themes were based on the sub-themes for each research question (see Appendix O).

Defining and naming themes. The initial sub-themes were then reviewed by considering the context within each research question and consolidating the sub-themes into themes. The researcher wrote memos within MAXQDA to analyze the data within the sub-themes and determine how the information answered the research questions. As part of this step in the process, Braun and Clarke (2006) suggested writing an analysis of each theme. To continue with the previous example of Setting High Level Technical Direction as a sub-theme, this sub-theme was combined with other sub-themes to answer the first research question: How do engineering leaders describe the utilization of technical skills in their leadership positions? The researcher created the following memo in MAXQDA which resulted in the creation of the themes for research question one: The overall theme in technical skills was the right level and use of technical background to help propel the team forward, problem solve, and drive direction without getting too involved in the technical details. The sub-themes and subsequent themes were the basis for providing answers to the research questions within the upcoming results section of this chapter.

Produce a report. Once the codes, sub-themes, and themes were created in MAXDQA, a report was generated to show each level of analysis. The analysis is represented in Appendix N. The upcoming Results section will discuss the results based on the analysis of information within the report.

Results

Study Findings – Northouse Skills Inventory Survey (2018). The results of the Northouse Skills Inventory Survey (2018) was an initial view into how the software engineering leaders utilized technical, human, and conceptual skills in their leadership positions. When looking at the individual participant's scores (see Appendix M), the total score for utilization of technical skills was 26.52, the total score for utilization of human skills was 26.91, and the total score for utilization of conceptual skills was 24.78. The max score for each skill set (technical, human, and conceptual) could be 30 if the participant answered *very true* to each question within the skill set. The total scores within all three skills areas were close to 30, which indicates the participants felt they utilized all three skill sets (technical, human, and conceptual) in their engineering leadership positions. Conceptual skills rated the lowest of the three skill sets, which was also a prevalent result in the interviews.

The aggregate data from the Northouse Skills Inventory Survey (2018) provided results for each survey statement based and mean and standard deviation of each statement (see Appendix L). The results were broken down in this section based on each research question. The Northouse Skills Inventory Survey (2018) consisted of 18 statements to address the three research questions. Statements 1, 4, 7, 10, 13, and 16 identified the leader's perceptions of their utilization of technical skills (RQ1). Statements 2, 5, 8, 11, 14, and 17 indicated the leader's perception of their utilization of human skills (RQ2). Statements 3, 6, 9, 12, 15, and 18 showed the leader's perception of their utilization of conceptual skills (RQ3).

Research Question 1 – Northouse Skills Inventory Survey (2018). The first question in the research study was: How do engineering leaders describe the utilization of technical skills in their leadership positions? To provide insight into this question, the researcher analyzed the mean and standard deviation scores from the Northouse Skills Inventory Survey (2018) statements 1, 4, 7, 10, 13, and 16. The survey was based on a 5-point Likert scale (1 = *not true*, 2 = *seldom true*, 3 = *occasionally true*, 4 = *somewhat true*, and 5 = *always true*). Survey statement 16, which asked participants to rate the statement "I understand how to do the basic things required of me." had the highest mean score of 4.78, with 82.61% responding as *very true*, 13.04% responding as *somewhat true*, and 4.35% responding as *occasionally true* which indicated that participants ranked this as an important skill.

The highest standard deviation among the technical skills survey statements was question number 10, which asked participants to respond to the statement "Following directions and filling out forms comes easy to me." with a standard deviation of 1.35. This indicated that there were a variety of responses as shown by 30.43% indicating *very true*, 26.09% indicating *somewhat true*, 21.74% indicating *occasionally true*, 8.70% indicating *seldom true*, and 13.04% indicating *not true*.

Research Question 2 – Northouse Skills Inventory Survey (2018). The second question in the research study was: How do engineering leaders describe the utilization of human skills in their leadership positions? To provide insight into this question, the researcher analyzed the mean and standard deviation scores from the Northouse Skills Inventory Survey (2018) statements 2, 5, 8, 11, 14, and 17. The responses from the survey statements were very similar in ratings, with the lowest mean score of 4.3 and the highest mean score of 4.74, indicating that the participants felt the statements regarding human skills were between *somewhat true* and *very true*. Similarly, the standard deviation between all participants had a very narrow range, with .53 at the low end and .77 at the high end. Thus, indicating there was a small deviation in the responses from participants.

Research Question 3 – Northouse Skills Inventory Survey (2018). The third question in the research study was: How do engineering leaders describe the utilization of conceptual skills in their leadership positions? To provide insight into this question, the researcher analyzed the mean and standard deviation scores from the Northouse Skills Inventory Survey (2018) statements 3, 6, 9, 12, 15, and 18. The responses from these statements in the survey were the lowest scores out of all the survey statements. For example, survey question 15, which asked participants to rate the statement "Creating a mission statement is rewarding work." had a mean of 3.65. Also, survey statement number nine, which asked participants to rate the statement "I am intrigued by complex organizational problems." had a mean score of 3.87. This was in line with the individual participant's scores, which showed conceptual skills as the least used skills among the participants.

Study findings - Interviews. Based on the data analysis of the interview data, the researcher identified six themes which support the research questions. The six themes that emerged from the in-depth interviews were:

1. Technical background can be utilized without involvement in technical details.
2. Technical background can be utilized to solve problems and provide technical direction.
3. Emotional intelligence skills are utilized to manage social awareness, self-awareness, and self-management.

4. Relationship management skills are utilized for effective communication and interaction with others.

5. Seeing the big picture based on strategic and critical thinking skills can be utilized to solve problems and drive direction.

6. Encouraging innovation through the ability to create fortuitous interactions and understand the business.

While each of the themes lined up with the research questions, there was also some overlap between the themes. For example, the attributes within the theme *relationship management skills are utilized for effective communication and interaction with others* was seen throughout the responses to the interview questions. This overlap will be called out within each section of the subsequent results for each research question. The results are organized by research question in relation to the themes and sub-themes identified in the data analysis to answer the overarching question: How do engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions? Table 5 shows the relationship between the research questions, sub-themes, and themes.

Research Question 1 - Interviews. The first question in the research study was: How do engineering leaders describe the utilization of technical skills in their leadership positions? To answer this question, the researcher analyzed in-depth interviews (questions 1, 2, 3, 10, and 11). Two themes surfaced based on the analysis of the interview data:

- Theme 1: Use of technical background without involvement in technical details.
- Theme 2: Technical background can be utilized to solve problems and provide technical direction.

Table 5.

Research Questions, Sub-Themes, and Themes

Research Questions	Sub-Themes	Themes
R1: How do engineering leaders describe the utilization of technical skills in their leadership positions?	Using a Technical Base Transitioning Away from Details	Technical background can be utilized without involvement in technical details.
	Setting High Level Technical Direction Problem-solving Skills	Technical background can be utilized to solve problems and provide technical direction.
R2: How do engineering leaders describe the utilization of human skills in their leadership positions?	Self-Awareness Self-Management Social Awareness	Emotional Intelligence skills are utilized to manage social awareness, self-awareness and self-management.
	Relationship Management	Relationship management skills are utilized for effective communication and interaction with others.
R3: How do engineering leaders describe the utilization of conceptual skills in their leadership positions?	Critical Thinking Skills Business Acumen Strategic Thinking Skills	Seeing the big picture based on strategic and critical thinking skills can be utilized to solve problems and drive direction.
	Ability to Encourage Innovation	Encouraging innovation through the ability to create fortuitous interactions and understand the business.

These themes were the result of four sub-themes that emerged from the analysis of the data: Using a Technical Base, Ability to Transitioning Away from Details, Setting High Level Technical Direction, and Problem-Solving Skills. The following sections will break down each of the sub-themes connected with the overall themes to answer research question one.

Within these themes, the researcher found variations in the responses, but the responses still fit within the overarching themes. For example, the majority of the software engineering leaders indicated that as they moved from individual contributor roles to leadership roles, they needed to move away from the technical details. Some of the leaders indicated that their technical expertise started getting in the way of their ability to lead the team. Other leaders felt their technical expertise was a pathway to help them become a better software engineering leader.

When transitioning into a leadership role, the software engineering leaders noted the importance of enabling, developing, and supporting their teams. Top-level leaders indicated they got involved with the technical aspects by looking for connections across the organization, while middle-level leaders tended to be more focused on getting involved with technical details within their own teams.

RQ1 - Sub-theme 1: Using a technical base. This sub-theme was generated by combining five codes from the interview questions (see Table 6). Engineering leaders indicated that they use their background in technology and software engineering to mentor and coach their teams. While the leaders indicated they are not in the details of the technology anymore, they did think it is important to stay abreast of the latest technologies to help guide their teams. Two of the engineering leaders felt it was important to help their teams understand best practices of software engineering. For example, Participant 12 stated “As a leader when I started learning new skills, I used those in a similar way to teach my leaders on what are the best practices, what should we be doing as an organization.”

Table 6.
RQ1-Sub-theme 1: Sub-theme, Codes, and Frequencies

Sub-theme	Codes	Frequencies
Using a Technical Base	Mentoring-Coaching	6
	Keeping up with Technology	11
	Identifying Best Practices	3
	Technical Understanding	40
	Technical Base to Build Relationships	21

Note. Frequencies are the number of times a word or phrase fit into the associated code.

Technical understanding had the largest frequency of codes discussed under the sub-theme of using a technical base. Although the leaders were not in the details, they indicated that understanding software engineering was important for them to be successful as an engineering leader. Participant 3 noted, “I do think having good technical skills to be able to be educated enough to have an opinion based on facts. But I do think you don't have to be the smartest person in the room.” Numerous responses from the in-depth interviews aligned with the code of *technical understanding*, such as the ability to manage software vendors, the ability to help with software designs, and applying engineering principles.

The second most frequently reported code within this sub-theme was having a technical base to *build relationships*. The responses in this section had a close relationship with research question number two regarding the utilization of human skills but were used in direct relation to the utilization of technical skills. For example, Participant 2 noted, “One of the reasons I'm able to deliver a lot of times than most of the time, on time and on budget is because I built those relationships with other people and work with them.” Participant 7 stated, “I think it [technical base] was the piece that gave me competence to be able to have those types of conversations where people could relate to me now that I actually knew what was going on, as well as being able to help them through challenges too." Overall, all 14 engineering leaders were in agreement that it was valuable for software engineering leaders to have a solid technical base with a good understanding of engineering principles to be effective when working with people inside and outside the organization.

RQ1 - Sub-theme 2: Transitioning away from details. This sub-theme was generated by combining four codes from the interview questions (see Table 7). The software engineering leaders indicated that as they moved from individual contributor roles to leadership roles, they needed to move away from the technical details. Some of the leaders indicated that their technical expertise started getting in the way of their ability to lead the team. Other leaders felt their technical expertise was a pathway to help them become a better software engineering leader. For example, Participant 4 said, "at the beginning, since I was coming from a pure developer background, I felt that my technology skills were actually coming in my way to manage people."

Table 7.
RQ1-Sub-theme 2: Sub-theme, Codes, and Frequencies

Sub-theme	Codes	Frequencies
Transition Away from Technical Details	Dependency on Team	6
	Transition Away from Details	24
	Less Use of Technical Skills	9
	Delegating	2

Note. Frequencies are the number of times a word or phrase fit into the associated code.

When transitioning into a leadership role, the software engineering leaders noted the importance of enabling, developing, and supporting their teams. For example, Participant 6 had this advice for upcoming engineering leaders: "Start soliciting answers from rest of the team and developing the relationship with them and help them when they need it. Pull back and generate, ask for their opinions but really build those relationships and partnerships and keep discussing." As seen in the previous sub-theme, this sub-theme also showed an overlap with research question two regarding the use of human skills.

Eleven of the 14 participants discussed the importance of transitioning away from the details, as is indicated by the large number of frequencies in this area. Some of the responses included statements such as Participant 1 who indicated, "I don't think my technical skills are needed to be super in-depth, such that I can go in and solve this from -- go in and code the solution. I don't think it needs to be there." Participant 7 stated, "I would tell you my technical expertise have definitely dwindled in terms of understanding what to do hands-on and being able to do things real-time." Participant 11 mentioned, "As you go higher up in the org, and you are managing managers and not individual contributors, those technical skills are still useful but not to the same extent as before." Participant 14 said "I want to understand what they're proposing and generally let them do their job and only interject myself when I really think we may be going down a wrong path or if I have concerns about a particular approach." Based on the responses, delegating technical responsibilities, and allowing the team to do the detailed technical work can allow the leader to focus on building other skills, such as human and conceptual skills. Overall, the engineering leaders agreed that they use their technical skills less as they have transitioned into leadership roles but had different perspectives on level of involvement in the technical details.

RQ1 - Sub-theme 3: Setting high level technical direction. This sub-theme was generated by combining two codes from the interview questions (see Table 8).

Table 8.
RQ1-Sub-theme 3: Sub-theme, Codes, and Frequencies

Sub-theme	Codes	Frequencies
Setting High Level Technical Direction	Guiding & Coordinating	20
	Technical Decisions	9

Note. Frequencies are the number of times a word or phrase fit into the associated code.

Although the leaders agreed that it is good to step away from the day-to-day technical details, they noted how it is still important to understand the technology enough to help guide the overall approach and technical/architectural direction. Participants indicated that a leader could help drive the vision and meet the objectives of the organization by ensuring the team is going in the right direction. One skill identified as part of setting the high-level technical direction was guiding the team by asking questions and generating discussion. For example, Participant 1 said:

> I'm more of a facilitator I guess is the way I would classify it, because, again, I'm not the subject matter expert nor do I want to be, nor do I think that's my role. It's to get the smart people in a room and drive to get a decision. Get a next step so that we can move forward.

Similar to guiding skills, Participant 13 identified coordinating as a key technical skill when describing the skill of setting the high-level technical direction:

> I'm not really involved in solving individual technical problems, it's more or less. If I do get involved with a technical problem, it's to guide and coordinate, "Hey, this thing feels like this. We need to get people together across org or across team." It's more about facilitating the right conversations and the right teamwork. It's not really about debugging anymore or re-engineering things.

When comparing the data from the interview questions with the data from the Northouse Skills Inventory Surveys (2018), this sub-theme is most closely aligned with question 10 “Following directions and filling out forms comes easily for me”. The responses to the survey statements showed 13.04% chose *not true,* 8.7% chose *seldom true*, 21.74% chose *occasionally true*, 26.09% chose *somewhat true*, and 30.43% chose *very true*. The responses to this survey question had the highest standard deviation at 1.35 which indicated that there was a wide range of perspectives on the ability to follow directions versus guiding and coordinating.

RQ1 - Sub-theme 4: Problem-solving skills. The last sub-theme, within the overarching theme of the use of technical background without involvement in technical details, was made up of four codes from the interview questions (see Table 9).

Table 9.
RQ1-Sub-theme 4: Sub-theme, Codes, and Frequencies

Sub-theme	Codes	Frequencies
Problem-solving Skills	Problem-solving	5
	Cross Team Problem-solving	5
	Asking the Right Questions	11
	Driving Technical Details	7

Note. Frequencies are the number of times a word or phrase fit into the associated code.

Problem-solving as an engineering leader is multi-faceted. In the higher-level leadership roles such as Vice President, software engineering leaders indicated they get involved with problem-solving by looking at patterns across multiple teams. For example, Participant 5, who was in a higher-level leadership role explained, “Taking data from many different places, assembling it together and framing it in questions that helps people, like broaden their horizons and see things from a different level.” Middle level leaders, such as managers, discussed how they dive into the details with their teams when a problem needs to be solved. Participant 2, who is in a middle management role, discussed problem-solving as, "Working with the team to understand those problems and working through how to best solve those." Regardless of the level of leadership, software engineering leaders agreed that one of their key skills was asking the right questions during problem-solving, which was also identified as a key skill.

Research Question 2 - Interviews. The second question in the research study was: How do engineering leaders describe the utilization of human skills in their leadership positions? To answer this question, the researcher analyzed the data from the in-depth interviews (questions 4, 5, 6, 10, and 11). Two themes surfaced based on the analysis of the data:

- Theme 3: Emotional intelligence skills are utilized to manage social awareness, self-awareness, and self-management.
- Theme 4: Relationship management skills are utilized for effective communication and interaction with others.

These themes were the result of four sub-themes that emerged from the analysis of the data: Self-Awareness, Self-Management, Social Awareness, and Relationship Management.

While the actual words *emotional intelligence* were not used by any of the respondents and was not mentioned in the Northouse Skills Inventory Survey (2018) questions, there was an overwhelming similarity with the definition of emotional intelligence as defined by Goleman (2000) which included self-awareness, empathy, motivation, social skills, and self-regulation. The data from the interviews regarding human skills closely aligned with the concepts discussed by Goleman, Boyatzis, and McKee (2013) regarding relationship management. Thus, these skills became the two themes to answer the question about the human skills utilized by engineering leaders.

Based on these connections, the researcher utilized these concepts of emotional intelligence in the sub-themes to answer research question two. The following sections break down each of the sub-themes connected with the overall themes to answer research Question Two.

RQ2 - Sub-theme 1: Self-Awareness. The term self-awareness was defined by Goleman (2000) as "the ability to read and understand your emotions as well as recognize their impact on work performance, relationships, and the like". This sub-theme was generated by combining four codes (see Table 10) from the analysis of answers and the direct connection to the definition of self-awareness from Goleman (2000).

Table 10.
RQ2-Sub-theme 1: Sub-theme, Codes, and Frequencies

Sub-theme	Codes	Frequencies
Self-Awareness	Knowing Yourself	2
	Empathy	1
	Aware When Wrong	2
	True to Yourself	2

Note. Frequencies are the number of times a word or phrase fit into the associated code.

Self-awareness was mentioned as an important skill for engineering leaders, such as the leaders ability to realize when they are not making a connection with someone and understand how their behavior is impacting others. Participant 5 admitted that this skill has been a challenge: "I have to slow myself down and I have to look for comprehension across the room and see if the people that are there are following. Some people, that comes very naturally to. That is not for me."

Participant 9 described the importance of taking the time to be introspective and honest with yourself about your ability to connect and communicate with people by saying, "I make sure that's really what I am because you have to be true to yourself."

Some engineering leaders noted that this skill did not come naturally to them. They must continuously work on it. There was a strong connection when comparing the results from the Northouse Skills Inventory Survey (2018) and the interviews in regard to the sub-theme of self-awareness. self-awareness an important skill in engineering leadership.

RQ2 - Sub-theme 2: Self-Management. Goleman (2000) broke down self-management into concepts such as self-control, trustworthiness, conscientiousness, adaptability, and achievement oriented. This sub-theme was generated by combining eight codes (see Table 11) from the analysis of answers and the direct connection to the concepts of self-management from Goleman (2000).

Table 11.
RQ2-Sub-theme 2: Sub-theme, Codes, and Frequencies

Sub-theme	Codes	Frequencies
Self-Management	Listening	1
	Staying in the Moment	1
	Controlling Frustrations	4
	Over Self Regulating	3
	Controlling What Sharing	1
	Self-control	7
	Calm, Cool, Collected	10
	Self-reflection	3

Note. Frequencies are the number of times a word or phrase fit into the associated code.

Self-management, the ability to control emotions (Goleman, 2000), was seen as very important by all the engineering leaders. One key code that surfaced from six of the engineering leaders was the ability to *stay calm, cool, and collected* during stressful situations. The impact of not staying calm in stressful situations was the risk of impacting relationships, which is a direction connection with the subsequent sub-theme of Relationship Management. Participant 7 described the importance of staying calm, cool and collected by saying:

> Because I think if you don't temper yourself, you run the risk of losing relationships within the in the organization, you can create bad perceptions on yourself and that's not good. I see that around me and when you get labeled for not having an even keel approach, nobody is gonna want to work with you and that to me is just absolutely not good. And that's why I think it's absolutely important to be able to self-control, temper yourself, manage through the challenges to the best of your ability. Otherwise, you'll end up putting yourself in a bad spot and I think you can lead to just very poor relationships going forward.

The engineering leaders indicated that it is challenging to work with someone who cannot temper themself and manage through challenges, which results in loss of respect and trust in your opinion. This can be seen by Participant 8 who commented, “if you show too much emotion, people can lose respect for you or they cannot trust your opinion.”

Additional codes that contributed to the sub-theme of self-management were *listening*, *staying in the moment*, and *self-reflection*. In other words, the ability to reflect and understand situations where you could have handled your emotions better. Participant 1 showed the practice of self-reflection by saying:

> Some of the stuff is reflection on myself, it was what didn’t I communicate or what did I do wrong? What could I have done better? At that point, I just stopped and then I had to start asking those questions like, "You were really interested in this. Now what happened? Tell me what gave you that interest? Why did you change your mind?" I think that's very important to do that.

Participant 14 mentioned a similar use of the self-reflection skill by explaining: “There are just many, many situations where I need to be careful, do that mental check and not get a knee jerk reaction.” While the code of *self-reflection* came up in the interviews, there was not a related Northouse Skills Inventory Survey (2018) statement to compare from an analysis perspective.

The second largest frequency code with the sub-theme of self-management was *self-control*. Goleman (2000) considered self-control as “the ability to keep disruptive emotions and impulses under control.” (p. 6). One of the interview questions under the human skills area was focused on the use of self-regulation as a skill within engineering leadership. Every leader agreed that the ability to control yourself is very important. One leader (Participant 5) was very specific about the importance of this skill:

> The higher you go in the organization and in those roles, the more important [self-management] is because you can't be a brilliant jerk. If you're a brilliant jerk, no one wants to work with you. And going back to that first thought of if you want to have an impact, you've got to work with others, then you are never going to be effective at having an impact if you're a jerk.

Another leader, Participant 3, indicated how challenging it can be to have self-control, especially in stressful situations such as layoffs, and gave the example “I wasn't as good at self-regulating when I was sharing with the teams I got fairly emotional and I felt unfortunate about it, that I couldn't have control that more”.

Three of the engineering leaders looked at self-control from a different perspective by bringing up the idea that too much self-control can be a bad skill for an engineering leader which led to the generation of a code called *over self-regulating*. For example, Participant 5 described the danger in too much self-control:

> Now the danger of self-regulation is there's certainly too much, because, there is a skill in knowing, there are times and places when it's appropriate to drop an F-bomb in the middle of a meeting. Some people might not do that because they're regulating too much and as a result, they lose their impact. Likewise, if you regulate so much and you want to make sure that everybody is included and nobody is included and you spend all of your time [socially] grooming everybody, you actually won't accomplish anything.

Participant 13 had similar thoughts about over self-regulating by relating it to engagement:

> I do think it's important, that self-regulation is important. I will use, well, I've been calling it hyperbole for impassioned speech maybe or situationally because I think-- I liken it to an audio thing. If you're monochromatic all the time I think after a while, your team doesn't know if you're engaged or not. I, also think, it's good to role model passion and ownership. The critical part of it is when you do use hyperbole, for me, my guiding principle is don't leave the motivation pot in shambles on the floor.

In addition to the discussion around self-control, the ability to control frustrations was also mentioned. Participant 11 had this to say about the ability to stay in control:

> I used to be impatient and I used to be impulsive in the past. But over the years I've become a lot more controlled and I don't speak out tone or I don't try to interject in conversations unless I feel like I have something to contribute that's valuable. I don't have to force myself to control. I think it's probably the opposite for me to just pick up a little bit more than what I normally do.

Other engineering leaders, such as Participant 12 had the same feelings: “I try to control myself internally to not get angry or frustrated at least [in front of] the people, when I'm working with them.”

RQ2 - Sub-theme 3: Social Awareness. Goleman (2000) broke down social awareness into concepts such empathy, organizational awareness, and service orientation. This sub-theme was generated by combining seven codes (see Table 12) from the analysis of answers and the direct connection to the concepts of social awareness from Goleman (2000).

Table 12.
RQ2-Sub-theme 3: Sub-theme, Codes, and Frequencies

Sub-theme	Codes	Frequencies
Social Awareness	Persuasion	1
	Empathy for others	9
	Influence (outcome)	4
	Navigating Politics	4
	Understanding People	7
	Understanding the Room	2
	Understanding Personalities	5

Note. Frequencies are the number of times a word or phrase fit into the associated code.

As mentioned above, one of the areas in emotional intelligence is social skills. The ability to influence as an engineering leader was discussed by many of the participants. During the interview questions focused on human skills, one of the questions asked what interpersonal skills were important as an engineering leader. Participant 5 was passionate about the answer to this question by saying:

> Influence-influence, and influence in that order. And by the way, influence is actually an outcome. The actual skill that leads you to be an influential person are the skills of being able to read a room, being able to understand the tone, and temperature of the room, being able to separate problems because usually, you

> walk into a room, you walk into a meeting, and everyone has five problems that all get conflated together to be the same thing. I need to adapt from that, so those things lead up to influence. Because, ultimately, the most successful leader[s], they're not successful because of where they sit in the organization.
>
> They're successful because they understand the business problems. They can tell a compelling story and they've built influence with the people that are necessary to build influence with and when you actually (and this is what I did) convince yourself that those are actually important and worthy problems to solve that you can take your engineering mindset and you can apply that engineering mindset to those problems, suddenly, the world opens up.

This response relates directly to the concepts discussed by Goleman (2000) around organizational awareness and service orientation. Other participants described influence within software engineering as the ability to combine technical knowledge with the ability to communicate why the problem is worth solving, understanding how to socially relate and communicate in a way that people can understand. For example, Participant 13 said:

> Influence a direction, then I'd say there's influencing skills. There's also, and I typically will combine the two, the influencing and collaboration and defining what's the value proposition for the collaboration or for what I'm proposing? What's in it for the person or team I'm trying to influence.

In addition to influence, the engineering leaders discussed the value in studying and understanding people by paying attention to body language, ability to read people, understanding personalities with many of them saying they wished they would have learned this as part of their engineering education. For example, Participant 4 explained:

> Because in a leadership role, it's very important for you to study people. As an engineer, you probably never paid attention to body languages.
>
> But as an engineering leader, you better start watching out on body, like looking at people and reading them and understanding what they think and see. So, in fact, people end up studying computer science, right? And they're really good at programming, that what I was when I did my bachelor's and my master's.
>
> But then, once you come out, maybe there are some folks that understand it quickly and say like, "Oh, okay," I need to really focus on the psychology part a little bit. The sooner you realize, the better off you are.

The leaders got into the engineering world because technology was easy for them, but they had to learn the social aspects, which was harder for many engineers. Part of understanding how to socially relate to others within the organization is understanding the politics, which leads to the code of *navigating political waters*.

Navigating political waters was a skill identified by various engineering leaders. This included collaboration with other teams, leaders, and their own teams to create win-win situations. The researcher initially identified this code as part of the conceptual skills interview questions, but as part of the data analysis, the code of *navigating political waters* was moved to the human skills section because it fit better into the sub-theme of social awareness. One of the participants (Participant 8) discussed this skill by stating "And then the interpersonal relationships and, unfortunately, politics in the office always come into play. And so, you think about that and, you know, how you can work with everybody to achieve the goal." In addition, Participant 1 acknowledge the importance of navigating politics and related it to conceptual skills such as strategic thinking:

> There's lots of politics that need to be navigated. So in this tool that we're in the process of creating right now, constantly my boss and I are thinking about how to navigate the political waters such that we're kinda balancing that act of creating a tool that we're not stepping on people's toes and we're getting them to want this, and so it's really more strategic thinking and positioning it in such a way that it's a win-win where, "Hey, we're working on this. We wanna collaboratively work on it," versus just build it and throw it over the fence and say, "Hey, here's this cool thing."

The largest frequency of responses within this sub-theme of social awareness was the code of being *empathic*. Participant 6 brought up the skill of empathy when asked which skills were used most in the engineer's leadership position. Their response was:

> Probably the biggest one is-- Let's see what the right word is to use for this. I think it's really empathy. Whether it's empathy for your engineers, or it's empathy for your customers, or it's empathy for your peers. That's probably the biggest one. The statements always made that people are the most important, most valuable resource that we have. Even if I was able to figure out how to code something and solve the problem, that's great, but the other 10 people can do that 10 times.

Other engineering leaders agreed that empathy was an important skill. Participant 5 said, "I can't understand how my behavior is affecting you unless I can put myself in your shoes." Participant 6 said, "I need to understand my customers to make sure I have empathy with them, to understand what it is that really is causing them pain." Participant 9 mentioned, "I try to look at things from their position. I use pretty much that to help me determine the best approach to work with people." Participant 11 said, "I would say it's empathy, your ability to listen to your people, understand what they're dealing with, and how you can help them to be successful in their roles."

In addition to the responses in the interview questions around social awareness, there was a specific statement in the Northouse Skills Inventory Survey (2018) related to social awareness: Statement five: "Being able to understand others is the most important part of my work". The participants responded by selecting *very true* at 73.91% and *somewhat true* at 21.74%. The response to this survey statements was a high-level view into the details found in the interview when discussing human skills.

RQ2 - Sub-theme 4: Relationship management. Goleman et al. (2013) described relationship management as a competency within emotional intelligence to build relationships and resolving conflict. This sub-theme was generated by combining three codes (see Table 13) from the analysis of answers and the direct connection to the concepts of relationship management (Goleman et al., 2013).

Table 13.
RQ2-Sub-theme 4: Sub-theme, Codes, and Frequencies

Sub-theme	Codes	Frequencies
Relationship Management	Ability to Interact with Others	89
	Communication Skills	55
	Relationship Building	19

Note. Frequencies are the number of times a word or phrase fit into the associated code.

This sub-theme had the smallest number of codes, but the largest number of frequencies within each code. Throughout the discussion about conceptual skills and specifically critical thinking skills, the skill of building relationships continued to surface as an important human skill. The engineering leaders indicated that having solid relationships was the foundation for being able to build and apply good critical thinking skills. While these codes were initially created under the Conceptual Skills area, they fit better in the Human Skills area under the sub-theme of Relationship Management. Good relationships and building rapport were mentioned in multiple aspects, such as the relationship with their teams, their peers, and stakeholders within the organization to meet the end goals. For example, Participant 3 noted, “I think the ability to get what is needed done based on my relationships.” When Participant 6 was asked question 11 in the interview regarding the guidance for upcoming engineering leaders, the participant answered, “Probably relationship and people skills.”

The code *ability to interact with others* had the highest frequency count out of all the codes in the human skills section. There are numerous components to this skill and various ways this skill can be used to be an effective engineering leader. One of the skills that was rolled into the ability to work with others was the skill of collaboration. Participant 1 showed this by saying:

> I think the number one skill that's needed for engineering leaders is the ability to collaborate with others, that's the thing I prioritize above all else, so whether that's me reaching out to my peers and or customers, the people we work closely with or my team works closely with to understand their needs and their view of the world so I can understand what it's like to be in their shoes.

Ten of the 14 engineering leaders who participated in the interviews felt collaboration was an important aspect of relationship management. The ability to work with others such as their teams, peers, and customers to understand their needs and share knowledge was very important. The ability to collaborate with people was identified as an important skill to be an effective engineering leader because many times, a problem spans across multiple entities. The engineering leaders indicated that having the relationships in place and actively work on collaborating within those relationships helps build your credibility as a leader.

Collaboration, the ability to interact with others, was also mentioned as a conceptual skill, but it fits better under the code of *ability to interact with others* within the relationship management sub-theme. For instance, Participant 2 discussed the importance of collaboration, “It's really just partnering with people, I guess, and trying to be transparent and collaborating.” Participant 5 described the importance of collaboration when in upper management roles:

> And when you become a manager of managers, you realize very quickly you're not going to be effective until you can start partnering with other people because the thing that you need to fix probably isn't just internal. Almost always the things that you need to fix require coordination across multiple entities and so you start to build this skillset of partnering with that peer group.

Participant 3 stated, “trying to ensure that it’s a collaborative environment, ensure that we're working well together.” When Participant 13 was asked what skill was used the most, the response was “I would say the most is collaboration. Making it a ‘we’, not an ‘I’ or a ‘you’”.

Another skill within the *ability to interact with others* code was the ability to be transparent when interacting with others such as being sincere and trustworthy and not having a hidden agenda. When working with their teams, the engineering leaders pointed out the importance of transparency because the team could see right through them if they were not being honest and upfront. Participant 7 indicated, “I'm a huge believer in transparency and the human element of that is that I think people think that you're more sincere and trustworthy in terms of what you're bringing to the table.” Participant 8 also discussed the value of transparency:

> And when you're dealing with very skilled, very professional people, they're going to see right through that [lack of trustworthiness]. And so, for me, it's transparency, it's being very direct with them and it's showing them that my goal is to make them successful because that will make the team successful.

An additional skill within the *ability to interact with others* code was conflict resolution. Conflict resolution was identified as an important aspect of the engineering leader’s role when interacting with their team and others within the organization. Two respondents described software engineering as a creative process that can be approached from many angles, which can lead to debates about how to solve a problem. For instance, Participant 10 stated “ability to deal with conflict has to be part of being a leader at a certain level because behavior is probably the thing I deal with probably the most.” Participant 13 had similar thoughts on conflict resolution:

> I find that in engineering there's a lot of strong opinions. You can easily derail something into a religious or political debate without really intending to. I do use similar techniques of asking open-ended questions and trying to help people come to the conclusions I would like them to.

In this case, the engineering leaders felt that the ability to ask questions (which was a key skill in the Technical Skill set to solve problems) and understand both sides of the story was important to help resolve conflict.

The last area of focus within the *ability to interact with others* code was responses from the participants about their interactions with their team, peers, stakeholders, and management. Numerous skill sets emerged when discussing how the engineering leaders interact with these people within the organization. When interacting with their teams, they identified key skills such as putting their employees first (using Servant Leadership) by being patient to enable and empower the team to help them grow. For example, Participant 9 said:

> So, that's always been my style [Servant Leadership]. When I show my, org chart, I'm at the bottom, so it's sort of the reverse triangle. I'm at the bottom there to support all my people. So, for anybody considered a subordinate on my org chart, I put them above me, so I'm here to serve them.

Many of the leaders discussed how helping the team grow by focusing on their personal development, personal relationships, and coaching can lead to stronger employee engagement. These skills of building a personal relationship were referred to as "managing the whole", meaning they take the time to understand what is going on with their teams at work and in their personal lives. Participant 1 said:

> You have to kinda understand everything going on to be able to effectively manage them while they're here and giving them the flexibility they need to know that "Hey, I know that this thing outside of work is really eating at you right now,

> why don't you go focus on that?", so that when you resolve that, you can be at your best self at work.

Although this was identified as an important skill, some of the leaders admitted it was not their strength. Participant 6 described a situation on the team:

> I have a senior DevOps engineer who is fantastic, he's absolutely fantastic. We moved him into the position after I fired his predecessor and his predecessor was probably even more skilled and technically advanced than he is. However, he actually made two people in the team cry because of his inability to provide constructive feedback and be supportive in the use of his knowledge and experience. That doesn't develop the team that I'm looking for.

When the engineering leaders discussed their interaction with their peers, different skill sets were identified (compared to the skills they use with their team). Various terms were used to describe how the engineering leaders worked with their peers, such as partnership and teammates. Overall, the engineering leaders agreed that having a relationship with their peers helped them be successful by sharing information, soliciting feedback, and understanding commonalities. Participant 2 described their relationship with peers:

> With my peers, a lot of time is just really if I need or have questions about something that maybe they've done that I haven't or come across yet. Just soliciting feedback from them or trying to get information from them on how maybe they've tackled a similar problem in the past.

Participant 14 had a similar response, “I am probably more likely to ask for advice of a peer on how to handle a situation than go to my staff, for example or even upper management.”

Interactions with stakeholders within and outside the organization brought different skill sets to the table. One of the skill sets identified was being an interpreter - the ability to translate the customer's pain points into a technical solution and the ability to explain technical situations in a language that the customer can understand. Participant 6 said, “Stakeholders, it's really two things. One of them is understanding them and what causes them pain. I already talked about it a little earlier, and the second one is reliability.” Some of the other skills mentioned in this area was the ability to be reliable, open, and honest when interacting with stakeholders to help drive solutions. For example, Participant 2 said, “With stakeholders, the best thing is to be open and honest about problems.”

When discussing how the engineering leaders interacted with upper management, a common skill emerged, which was the ability to be brief and to the point by using crisp communication to provide the right level of information and ensure there is alignment in direction. Participant 6 showed this with the comment “upper management probably the biggest thing there is alignment and making sure that I can communicate that this is what's important. Understanding what's important to them.”

Overall, the ability to interact with people at all levels within the organization became a key skill for engineering leaders and lead to the creation of the sub-theme of relationship management. Understanding how to tailor the communication and build relationships was tightly coupled with this skillset. *Communication* and *building* *relationships* were the other two codes that factored into the creation of the relationship management sub-theme.

Communication was mentioned consistently throughout the interviews within the technical skills questions, human skills questions, and conceptual skills questions. The responses were combined together into the sub-theme of Relationship Management based on the information from Goleman et al. (2013). The terms used to describe communication skills by the engineering leaders included listening, openness, and honesty. For example, Participant 1 explained the importance of open and frequent communication "being able to communicate with them openly and frequently such that expectations are set, and they know what we're doing and why. And always being sure we are on the same page." The other key component of communication was the need to work with a variety of people throughout the organization. Participant 4 described this:

> So, engineering leaders, I may need to be able to work with the business partners. Need to be able to work with obviously the team, internal and external customers, and with senior leadership, right. So, there are multiple flavors of people that you need to work with. The level of detail that you pass on to a developer is going to be very different compared to the leadership chain who really wants to hear the summary of the problem. And the business partner might be interested in like metrics. So, there is always a different language that you have to use between the different sections of folks. To answer your question, it is very important trait for somebody as an engineering manager, communication is crucial.

Communication was also tied to the ability to influence within the organization. This can be seen by how Participant 5 talked about the value of effective communication:

> If you can't effectively communicate that idea, and if you can't influence the right people, you're just going to be the really smart guy that everybody laughs at and ignores and goes about their day. If you actually make a difference and have an impact, you've got to care about the people. You've got to care about how your message is received, and you've got to communicate it in a way that makes sense to other people. Not just to you.

Participant 10 felt communication skills were extremely important and factored that into decision making during the hiring process:

> Communication skills are probably high on my list in order to pull off almost anything, any interpersonal skills is probably higher in my hiring process than probably technical skills in probably like 20% of my decision making. Because I can have the smartest person in the room, but if they're a jerk, you know, nobody wants to work with them. It's gonna slow down production, everything, right?

Participant 8 talked about how communication is used all day long, every day by engineering leaders:

> I would say nowadays, communication is far and away the most [important skill]. And that's a broad category. But- you know, I'm on my emails throughout the day, texting, walking over and talking to people in the office, talking to my development team, making sure they understand what's going on, working on reports, bugs, those kinds of things. So, the communication far more than when I was a hands-on developer applies to leadership position. It's constant communication to make sure everyone tries to stay in sync and has the same ideas going forward. So, no one's misunderstanding.

Many of the engineering leaders indicated that communication was one of the most important skills for upcoming engineering leaders. Participant 12 said “I'm bringing a manager or developer under me - grooming him to be my leader. Then one of the big things that I expect, or I continue to teach them is good, strong communication skills.” Participant 13 also agreed with communication being a critical skill:

> Communication. I think it's a big challenge and we, especially, in technology, and you probably have seen this, we value all the technical checkmarks on someone's resume, and I've got this much of JavaScript, this much of back end, blah blah blah, but the thing that I've seen impact, adversely, more projects and more features than not is communication, either the inability to articulate a solution or the inability to engage active listening to really understand what you're delivering and if you're solving, so by far - communication.

The final code identified under the sub-theme of Relationship Management was *relationship building*. Although this code has similar characteristics as other codes, such as to the *ability to interact with others* and *communication*, it had responses from nine of the 14 interviewees, and thus warranted its own analysis and ultimately its own sub-theme. Participant 3 provided a general statement about relationship building “I think the ability to get what is needed done based on my relationships.” Participant 2 also chimed in with the statement:

> A lot of it's networking to a certain degree, understanding who to contact for certain situations and just understanding when to reach out to them for looping them into things that we're working on just to give them a heads up.

Participant 8 learned the importance of relationship building when becoming a manager:

> And so I had to watch that as I became the manager because there would be certain people around the organization that I may have had a bit less respect for than other people but I still had to put on my management base, do my best to work with them and, you know, get the project to succeed.

Participant 4 described the importance of solid relationships based on seeing how people react to leaders who are not interested in building relationships:

> Because there are some leaders based on my experiences. I have seen leaders ask questions in a fighting squad mode where the folks just going to their shell and they're like, "Okay, it doesn't matter what I do.", this guy is not appreciative of anything that I do. I am not going answer his questions or think of one step ahead.

The amount of responses associated with the sub-theme of Relationship Management can be compared to the responses within the Northouse Skills Inventory Survey (2018) that are associated with Relationship Management. Question 2 in the Northouse Skills Inventory Survey (2018) asked respondents to rate: "As a rule, adapting ideas to people's needs is relatively easy for me." The participants responded with 95.65% as *very true* or *somewhat true*. Statement 8 asked participants to evaluate: "My main concern is to have a supportive communication climate.", which had results spread across three responses such as 52.17% *very true*, 34.78% as *somewhat true,* and 13.04% as *occasionally true*. The responses to this statement and the details in the interview regarding communication did not directly match up and will be discussed more in Chapter 5.

Research Question 3 - Interviews. The third question in the research study was: How do engineering leaders describe the utilization of conceptual skills in their leadership positions? To answer this question, the researcher analyzed the in-depth interviews (questions 7, 8, 9, 10, and 11). Two themes surfaced based on the analysis of the data:

- Theme 5: Seeing the big picture based on strategic and critical thinking skills can be utilized to solve problems and drive direction.
- Theme 6: Encouraging innovation through the ability to create fortuitous interactions and understand the business.

These themes were the result of four sub-themes that emerged from the analysis of the data: Critical Thinking Skills, Business Acumen, Strategic Thinking Skills, and Ability to Encourage Innovation.

RQ3 - Sub-theme 1: Critical thinking skills. This sub-theme was generated by combining six codes (see Table 14) based on the analysis of the interview questions. Out of the six codes, the skill of *Asking Questions* and *Problem-solving* were key areas of focus in the responses from the participants.

Table 14.
RQ3-Sub-theme 1: Sub-theme, Codes, and Frequencies

Sub-theme	Codes	Frequencies
Critical Thinking Skills	Identifying Key Players	2
	Negotiation	2
	Decision Making	3
	Asking Questions	17
	Understanding the Why	2
	Problem-solving	16

Note. Frequencies are the number of times a word or phrase fit into the associated code.

When discussing critical thinking skills, engineering leaders emphasized the ability to ask questions that will help the team think about a problem differently. Such terms as edge thinking, thinking outside the box, and big picture views were used by the participants when describing this skill. Engineering leaders stressed how asking questions leads to improved analysis of a problem. For example, Participant 4 described the use of critical thinking skills that also relates to human skills by saying:

> I would be asking some powerful questions so that they think out of the box. If they are talking through a solution, this is what this is, this is the architecture that I'm proposing, then you wear that critical hat saying, "Okay." So how about this use case? Do you think that the way things are designed, do you think it's going to work for that use case? It's all about building that rapport, making sure that they feel comfortable with the questions, not threatened.

Other participants had similar responses regarding the focus on asking questions, such as Participant 5 who said, “that's the key of the critical thinking is also asking me, what's the alternative?" and Participant 6 who indicated, “There’s a lot of stating the problem, understanding the situation, understanding constraints that we have, asking a bunch of questions around why, where and how.” Each participant described how they use their critical thinking skills but had a variety of techniques for asking the right questions. Participant 9 used a technique called the GROW model which was described as, “What's the goal? What are the roadblocks? What are the options to overcome the roadblocks? And then what are we willing, the W is what are we willing to pursue?” Others took a different perspective, such as Participant 10 who said:

> The point is that when the obvious things worked on you, what are you thinking that's not obvious? What else can you do to dig and research? How do you keep track of that information, so you don't keep going in circles and start to eliminate things? I definitely feel when you're solving for bugs that you'd never seen before, it's very important. I think critical skill is very important as you jump into code.

In addition to asking questions to help their teams think through situations, two participants related this skill to big picture thinking, such as Participant 6 who said:

> The trick to it is understanding, again back to the big picture, "Okay, here's the end state, here's the end goal, here's the end vision as to how this really should operate, and this is the best-case scenario. We're either here and we haven't done anything, or we've done something, but it's not like this."

Participant 5 also described the importance of seeing the big picture, "taking data from many different places, assembling it together and framing it in questions that helps people, like broaden their horizons and see things from a different level."

In addition to asking questions, the engineering leaders described the importance of problem-solving skills such as breaking down the problem, framing the problem, driving the conversation (which was also mentioned in technical skills), putting the pieces together, identifying dependencies, and creating a plan. Thus, problem-solving became a code within the sub-theme of critical thinking skills. Participant 6 demonstrated the concept of problem-solving in a leadership role: "You learn that as management it's our responsibility to solve this problem and making sure that we all are on the same page about solving the problem." Participant 9 focused on problem-solving from a planning perspective "I'm a planner and I can help people get out of the whirlwind and create a plan." Participant 7 brought an additional perspective to problem-solving by saying:

> I think it's extremely important to figure out how to be able to break those down into tangible items that are workable. Sometimes we get more enamored with the problems in front of us, rather than looking at it and saying, "I can handle that. Let me figure out how to break that down. Take it piece by piece, and then rationalize

> it into a bigger plan". Because I think if you try to, you know, it sounds like a cliché, but boil the ocean on everything you'll never get anything done and that won't work either. Those are probably the three tactics that I would leverage to figure out how to attack those complex problems.

The last area of significant information on problem-solving came from Participant 9 who talked about problem-solving from a big picture perspective by stating:

> I use that [problem-solving] a lot with our cross-team or cross-organization plans. We sit down and bring people together and say, "What is our overarching goal that we all kinda align on?" If we can align on that, people immediately want to go into designs and how we're gonna fix the problem.

When comparing the data from the interview responses regarding problem-solving and the Northouse Skills Inventory Survey (2018) statements, a connection was identified between survey statement nine, which asked respondents "if they were intrigued by complex organizational problems" and problem-solving responses in the interviews. The survey responses showed a variety of perspectives such as 26.09% said this was *very true*, 39.13% said this was *somewhat true*, 30.43% said this was *occasionally true*, and 4.37% said this was *seldom true*. The survey statement was centered on organizational problems, compared to the interview responses, which were more focused on solving problems within teams. Overall, the sub-theme of critical thinking skills identified by the engineering leaders focused on the ability to ask the right questions and help the organization solve problems while considering the big picture.

RQ3 - Sub-theme 2: Strategic Thinking Skills. This sub-theme was generated by combining three codes (see Table 15) based on the analysis of the interview questions.

Strategic thinking skills included tactics such as positioning a solution as a win-win, thinking big picture, and knowing where to go (architecture direction). Four of the engineering leaders explained how they used strategic thinking skills as part of their everyday role to ensure they were directing the team in the right direction. The responses led to the creation of the code called *Architecture Direction*. Examples such as creating architecture diagrams or figuring out ways to improve efficiencies were mentioned by Participant 2, “The way I've worked across those teams was, I put together basically an architectural diagram that showed how things are working in current state and then what we'll need to do on future state.” These tied back to the technical skills related to using a technical base to set a high-level direction.

Table 15.
RQ3-Sub-theme 2: Sub-theme, Codes, and Frequencies

Sub-theme	Codes	Frequencies
Strategic Thinking Skills	Architecture Direction	5
	Big Picture	5
	Forward Thinking	6

Note. Frequencies are the number of times a word or phrase fit into the associated code.

Big picture was identified as a code within the sub-theme of strategic thinking skills. Participant 11 described big picture skills, “It's always important to understand the big picture and how you fit into that big picture and how you can work within the organization to deliver what you have to deliver.” In addition, Participant 13 noted how software engineers do not think about the big picture, so it is important for the engineering leader to help guide the team:

> They [software engineers] very rarely think about how it fits in the grand scheme of things or along a thread of what the capability is that our software does, most

> of it is really getting them to confirm what is the true requirement here, let's talk about how you use that whole capability.

Participant 3 described the progression of conceptual skills around seeing the big picture by saying:

> Prior roles, I've been a little more limited in a team focus and smaller group focus and I've been kind of aware of the bigger picture, but I think now I'm trying to have that be a more important aspect of what I'm thinking about and thinking more broadly.

Participant 2 indicated less use of strategic thinking on a daily basis, "I think that strategic in my experience, that strategic planning is less frequent, which is something you revisit periodically."

Two of the engineering leaders described how their peers are too much in the day-to-day details instead of planning for the future and noted how these types of skills come into play when leading at the mid-level and above. Thus, the code of *forward thinking* was identified as an important skill. For example, Participant 7 indicated:

> They [other engineering leaders] lose the forward-thinking, they forget how to enable the workforce. And to me you've got to be able to look at all of those in parallel, and try and think, you know, six months, nine months out there on how you bring all those things together.

Participant 8 also discussed the importance of forward thinking by saying, "here's where we are today, but what are we going to need in a few months or what unexpected thing may come up?"

There were numerous statements within the Northouse Skills Inventory Survey (2018) that aligned with the sub-theme of strategic thinking from the interviews. Survey statement number 3, “I enjoy working with abstract ideas” generated a variety of responses such as 30.43% selecting *very true*, 47.83% selecting *somewhat true*, and 21.74% selecting *occasionally true*. Survey statement number 6 also showed a connection with strategic thinking when asking about how participants felt about seeing the big picture. In this case, all respondents either selected *very true* or *somewhat true*. This survey statement had the lowest standard deviation (0.5) out of all the survey responses, which indicated that the engineering leaders were in general agreement on the skill of seeing the big picture, which was also seen in the interview data. While the concepts within the sub-theme of strategic thinking were not as frequent as the codes identified in the sub-theme of critical thinking skills, the engineering leaders all mentioned how they try to drive the direction of the organization in their engineering leadership roles.

RQ3 - Sub-theme 3: Ability to Encourage Innovation. This sub-theme was generated by combining two codes (see Table 16) based on the analysis of the interview questions.

Table 16.
RQ3-Sub-theme 3: Sub-theme, Codes, and Frequencies

Sub-theme	Codes	Frequencies
Ability to Encourage Innovation	Grounding Innovation in Reality	15
	Creating Fortuitous Interactions	3

Note. Frequencies are the number of times a word or phrase fit into the associated code.

All the engineering leaders noted the importance of encouraging innovation but indicated it must be done within the right context. This led to the creation of the code *grounding innovation in reality* within the sub-theme of ability to encourage innovation.

For instance, participants described the importance of focusing on solving a real business problems and grounding in current technology. For instance, Participant 9 said, “embrace innovation as long as it's grounded in some sense of reality and current technology.” Participant 2 said, “We're usually innovating around the context of a problem.” Participant 13 had a similar perspective:

> It's very seldom free form, "Well, let's just innovate," I say in the current role, the innovation is more about looking at business processes, looking at where technology can help out, that's really the innovation that I'm dealing with now.

Similarly, Participant 14 said, “Being in a technical industry, the tools, the technologies can frequently change, and it is important for technical currency, but you have to balance that with not making decisions on technology for technology's sake.”

The conceptual skill that comes into play with innovation is not the innovation itself; it is the skill of balancing innovation while continuing to meet the needs of the business. For example, Participant 10 noted, “as a leader, I've had to buy into the business that I need time for innovation.” Thus, the engineering leaders connected the skill of looking at things from a strategic perspective and knowing how to make innovation valuable for the organization.

Two of the engineering leaders described how they encourage innovation by creating a safe environment, providing avenues for the team to participate in innovation activities (fortuitous interactions), and asking the right questions to spark new ideas. These responses led to the creation of a code called *creating fortuitous interactions* within the sub-theme of ability to encourage innovation. For example, Participant 5 said:

> As a leader, you can absolutely control the rate of innovation based on how frequently you're creating an environment for those fortuitous interactions to happen. And just by human nature, you're creating an environment where people are going to be running into each other and you're encouraging that sort of sharing of ideas and keeping aware of what other people are working on so that people can identify those commonalities.

Participant 3 had a similar idea about the value of pulling people together:

> I think the more we're learning about what everyone else is trying to do, then, encouraging a partnership with someone else in a different functional area to say, we should try to figure out how we can help solve this. Let's get together and brainstorm and come up with some ideas and if we want to pull in other people and that kind of thing, but I think trying to identify based on the challenges and the different initiatives. What are some things that we could propose to help solve the business capabilities that they're trying to develop.

Many of the engineering leaders provided examples of how innovation is done within their organizations. Initially these were coded as part of this section, but later removed because they did not have anything to do with the actual skill of encouraging innovation. The descriptions were the 'what', not the 'how' such as Tech-Talk Tuesday, Technology Bake-Offs, and Proof of Concepts. Overall, based on the responses within this sub-theme, the engineering leaders showed that encouraging innovation was a combination of strategic thinking and critical thinking skills.

RQ3 - Sub-theme 4: Business Acumen. This sub-theme was generated by identifying one code (see Table 17) based on the analysis of the interview questions.

Table 17.
RQ3-Sub-theme 4: Sub-theme, Codes, and Frequencies

Sub-theme	Codes	Frequencies
Business Acumen	Ability to Understand the Business	4

Note. Frequencies are the number of times a word or phrase fit into the associated code.

The final sub-theme under Conceptual skills was business acumen, with one code labeled *ability to understand the business*. Participant 5 discussed the importance of understanding the business:

> First and foremost, is actually learn the business context in which you're in. How does the company make money? How does the company spend money? How much is desirable and how much is undesirable. The earlier that you can start putting your work into that business context, the sooner you're able to build the influence, the sooner you're able to motivate people. Being able to create the view of, "This is the world, and this is where we fit."

Participant 12 had a similar thought when describing the importance of helping the team understand the business perspective “It's almost a business level that I have to sit with them and explain.”

The Northouse Skills Inventory Survey (2018) question that was similar to the sub-theme of Business Acumen was statement number 15, “Creating a mission statement is rewarding work.” In the Northouse Skills Inventory Survey (2018), there was a wide range of responses, with one participant indicating this statement was *not true*, two participants indicated *seldom true*, six participants indicated *occasionally true*, nine participants indicated *somewhat true*, and five participants indicated *very true*. This survey statement had the lowest mean score (3.65) out of all the survey statements. The survey responses aligned closely with the small number of interview responses around the skill set of understanding business acumen. The researcher kept this sub-theme in the study because the responses were from upper level engineering leaders, which had implications in the summary findings within Chapter 5.

Summary

In Chapter 4, the researcher focused on the data analysis and results to answer the three research questions: (R1) How do engineering leaders describe the utilization of technical skills in their leadership positions, (R2) How do engineering leaders describe the utilization of human skills in their leadership positions, and (R3) How do engineering leaders describe the utilization of conceptual skills in their leadership positions? Data was gathered via Northouse Skills Inventory Survey (2018) and in-depth interviews from software engineering leaders who reside in the United States, had more than two years of experience in leadership within the information technology field, and were connected to the researcher's LinkedIn network of engineering leaders.

Purposive sampling was used to recruit software engineering leaders from the researcher's LinkedIn account. Yin (2016) suggested purposive sampling as a way to select participants based on the richness of answers to the research questions. Twenty-three engineering leaders opted to participate in the Northouse Skills Inventory Survey (2018) by agreeing to the informed consent, completing the demographic information questions, and answering the survey questions. After each Northouse Skills Inventory Survey (2018) was completed, the researcher contacted the participant to schedule an individual interview. The researcher started seeing repetitive information after the 12th interview but continued to complete two additional interviews to ensure saturation. After the 14th interview, there was no new information, so the researcher was confident that data saturation had been met.

The survey used for this study was the Northouse Skills Inventory Survey (2018) based on Katz's (1955) theory of the three skills (technical, human, and conceptual) for effective leaders. The Northouse Skills Inventory Survey (2018) was administered via SurveyMonkey. The names of the participants were changed to Participant 1, Participant 2, etc. to keep the identity of the engineering leaders confidential. The individual participant's scores were calculated for each survey. The mean and standard deviation were calculated for the survey responses and described in the results. The individual participant's survey data scores and aggregate (mean and standard deviation) scores for each survey response can be seen in Appendices L and M.

The in-depth interviews were used to get more detailed information on the skills used by software engineering leaders. The interview questions were created to answer the research questions and were based on the Katz (1955) skills-based model of technical skills, human skills, and conceptual skills. The researcher used thematic analysis and an inductive approach to analyze the interview data using the six-step process as suggested by Braun and Clarke (2006). These steps included becoming familiar with the data, generating initial codes, searching for themes, reviewing the themes, defining, and naming the themes, and producing a report (Braun & Clarke, 2006).

During the first step of the data analysis of the interview data, the researcher became immersed in the data by re-watching the video recordings of the interviews multiple times and validating the accuracy of the transcripts. The researcher also removed the names of the participants from the interviews by changing the names to Participant 1, Participant 2, etc. for all participants in the interviews. The researcher made sure the participants who completed both the Northouse Skills Inventory Survey (2018) and interviews had the same participant number to keep track of the participants.

The second step in the data analysis involved organizing the data in preparation to load in to MAXQDA. Oliveira et al. (2016) noted the benefit of MAXQDA software as a valuable tool for qualitative studies based on the ease of use in coding and presenting results. The interview data was broken out by participant and research question before loading into MAXQDA. The researcher used a combination of descriptive and In Vivo coding within MAXQDA to identify the initial codes. The codes were analyzed and grouped into broader code names based in similarities. Saldaña (2015) suggested grouping similar codes together, using selected codes repeatedly, and creating sub-themes of codes.

The third step involved searching for themes within the codes generated in step two of the analysis process. The researcher used the Memo feature within MAXQDA to help synthesize the meanings behind the codes and create sub-themes. Four sub-themes were generated and then rolled up to two themes to answer the first research question: How do engineering leaders describe the utilization of technical skills in their leadership positions? These sub-themes were Use of Technical Base, Transition Away from Details, Setting High Level Technical Direction, and Problem-Solving Skills. The two themes that addressed research question one were:

- Theme 1: Technical background can be utilized without involvement in technical details
- Theme 2: Technical background can be utilized to solve problems and provide technical direction.

To address the second research question: How do engineering leaders describe the utilization of human skills in their leadership positions? The four sub-themes were created Self-Awareness, Self-Management, Social Awareness, and Relationship Management. These four sub-themes evolved into two themes for research question two:

- Theme 3: Emotional intelligence skills are utilized to manage social awareness, self-awareness, and self-management.
- Theme 4: Relationship management skills are utilized for effective communication and interaction with others.

Four sub-themes were created for the third research question: How do engineering leaders describe the utilization of conceptual skills in their leadership positions? These sub-themes were Critical Thinking Skills, Strategic Thinking Skills, Ability to Encourage Innovation, and Business Acumen. These four sub-themes were collapsed into two themes that answered research question three:

- Theme 5: Seeing the big picture based on strategic and critical thinking skills can be utilized to solve problems and drive direction.
- Theme 6: Encouraging innovation through the ability to create fortuitous interactions and understand the business.

After creating the sub-themes, the researcher moved on to step four, which was reviewing the themes. The details of the sub-themes were analyzed by creating a codebook that showed the interview responses in relation to the codes and the subsequent sub-themes (see Appendix N). The researcher searched for patterns across the sub-themes to determine the overarching themes to answer the research questions.

The final step in the thematic analysis process was the generation of the report. The data captured in MAXQDA was exported to a MSWord document and divided up into various sub-themes based on the research questions. For example, the first set of data contained the list of codes, sample quotes, and frequencies for each research question.

The second section of the codebook described the sub-themes, codes, and analytic memos. The third section of the codebook showed the research questions, themes, and sub-themes.

Certain limitations emerged based on the data analysis. One of the limitations that was initially identified in Chapter 1 was how busy engineering leaders are with their daily job responsibilities. This was seen during the data recruitment phase of the study when some potential participants opted out of doing the in-depth interviews based on time constraints with their jobs and families. The researcher was able to overcome this limitation due to having a reserve pool of participants who had completed the Northouse Skills Inventory Survey (2018) and were willing to participate in the interviews.

A second limitation that was identified prior to conducting the study was the prior connections that the researcher had with potential participants which could introduce bias on the part of the researcher. Based on the fact that the researcher's LinkedIn account was used to connect with the engineering leaders, the researcher did have prior relationships with some of the participants. The researcher overcame this limitation through reflexivity during the interviews by strictly adhering to the interview protocol during the interview process and removing the names of participants from the Northouse Skills Inventory Survey (2018) and interviews before starting analysis.

One additional limitation that the researcher realized during data analysis was the novice aspect of analyzing large amounts of data. This was the first time the researcher had experienced analyzing data through the six-step thematic process and the first time using MAXQDA. This resulted in the data analysis process taking longer than expected and required additional research on how to utilize MAXQDA in the most logical, effective manner. Given the fact that the researcher was the only person involved in this study, the resulting codes, sub-themes, and theme were based on only the researcher's perspective. If additional researchers were involved with the study, the codes, sub-themes, and themes could have been validated for increased reliability.

Chapter 5 will include a detailed summary of the study, including the findings, conclusions, and implications. This chapter will show how this research study contributed to the body of knowledge and how the information discovered in the study relates or extends the existing literature to fill the gap identified at the beginning of the study. The researcher will point out the most important aspects of the study, the theoretical and practical implications, and describe the strengths and weaknesses. Recommendations for future studies and future practices will be included to continue to expand on the field of engineering leadership.

Chapter 5: Summary, Conclusions, and Recommendations

Introduction and Summary of Study

Technology has become increasingly important to help organizations stay competitive in the global economy. The function of information technology continues to grow and advance within organizations, with a focus on software engineering, systems analysis, and other technology-focused disciplines (Beckhusen, 2016). As information technology becomes more important for organizations, so does the need for software engineering leaders. Perri et al. (2019) noted how software engineering leaders play a key role in delivering tools to help businesses stay competitive. Gaining a better understanding of the skills utilized by current software engineering leaders is valuable to prepare upcoming leaders. Thus, the intent of this study was to explore how software engineering leaders utilize technical skills, human skills, and conceptual skills in their engineering leadership positions.

In this study, the utilization of engineering leadership skills was explored using the theoretical foundation developed by Katz (1955), who posited that effective leaders use a combination of technical, human, and conceptual skills in their leadership positions. Rottmann et al. (2016) investigated engineering leadership by conducting studies with a variety of people within organizations but had not explored the utilization of leadership skills by software engineering leaders within the information technology field in the United States. Kalliamvakou et al. (2017) studied engineering leadership and found different results regarding the use of technical skills as compared to the results found by Rottmann et al. (2016). Boyatzis et al. (2017) conducted a study on engineering effectiveness in relation to emotional intelligence but did not include engineering leaders.

In addition, conceptual skills have been studied with a focus on project managers (Obradović et al., 2018) but not as conceptual skills pertain to software engineering leaders. Based on the above gaps in current literature, and discrepancies in findings among research studies, this study added to the body of knowledge by exploring engineering leadership skills based on real-world experiences of software engineering leaders.

The utilization of engineering leadership skills was explored using the following research questions to guide this qualitative descriptive study:

RQ1: How do engineering leaders describe the utilization of technical skills in their leadership positions?

RQ2: How do engineering leaders describe the utilization of human skills in their leadership positions?

RQ3: How do engineering leaders describe the utilization of conceptual skills in their leadership positions?

This researcher used the Northouse Skills Inventory Survey (2018) and in-depth interviews to obtain real-world perspectives from engineering leaders. The Northouse Skills Inventory Surveys (2018) were analyzed based on the close-ended responses and the in-depth interviews were analyzed based on the open-ended responses. Frequency counts, mean values, and standard deviations were computed for the scores from the Northouse Skills Inventory Survey (2018). The responses from Northouse's (2018) skills inventory were grouped and calculated to obtain a score for utilization of the three skills: technical, human, and conceptual. Individual participant's scores were also calculated for the three survey areas (technical, human, and conceptual skills) to align with the three research questions.

The individual interview questions were created by the researcher, based on concepts from Katz's (1955) three skills model and on information from previous engineering leadership studies (Boyatzis et al., 2017; Kalliamvakou et al., 2017; Medcof, 2017; Racine, 2015; Rottmann et al., 2015, 2016), as described in Chapter 2. A thematic analysis recommended by Braun and Clarke (2006) was used to analyze the open-ended in-depth interview responses. The data analysis from the interviews resulted in the generation of themes to answer the research questions of how software engineering leaders utilize technical, human, and conceptual skills in their leadership positions.

This study proved to be important by adding to the body of knowledge on engineering leadership from real-world descriptions by software engineering leaders. The study was designed to describe how software engineering leaders utilized technical, human, and conceptual skills. The participants in the in-depth interviews were enthusiastic about sharing their knowledge on engineering leadership, which led to robust responses. The key findings that supported prior studies (Kalliamvakou et al., 2017; Rottmann et al., 2015, 2016) and new data that added to the body of knowledge on engineering leadership will be described in this chapter.

The remainder of this chapter will focus on providing a summary of the findings based on the data analysis and results from Chapter 4, along with a comparison to the existing literature on engineering leadership. Implications from this research study will be discussed in relation to the theoretical foundation, practical applications, and implications for future research. The strengths and weaknesses of the study will be discussed as well as recommendations for practitioners and future researchers.

Summary of Findings and Conclusion

The purpose of this study was to explore how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions within the information technology field in the United States. The intent of the researcher was to gain insights into skills utilized by real-world software engineering leaders to continue the discussion on engineering leadership by providing research on specific skills needed to be effective in engineering leadership positions. Broy (2018) described the importance of ongoing education of engineering leaders to meet the demands of data-driven organizations. Rottmann et al. (2016) studied engineering leadership based on samples from engineers, human resources personnel, and entrepreneurs but lacked data from software engineering leaders. There were discrepancies among research studies regarding the utilization of technical, human, and conceptual skills in engineering leadership (Kalliamvakou et al., 2017; Rottmann et al., 2016). To summarize, research was needed into how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions (Boyatzis et al., 2017; Kalliamvakou et al., 2017; Medcof, 2017; Racine, 2015; Rottmann et al., 2016). This study addressed this gap in research by exploring the utilization of leadership skills from the perspective of software engineering leaders through the lens of Katz's (1955) three skills for effective leadership.

The data collected by the researcher in this study answered the three research questions based on the utilization of technical skills, human skills, and conceptual skills in engineering leadership positions. Interview data from the study has resulted in six themes based on twelve sub-themes described by software engineering leaders who had at least two years of leadership experience in the information technology field and reside in the United States. The summary of the findings presented below is organized by research question and the themes/sub-themes within each research question.

Research Question 1. How do engineering leaders describe the utilization of technical skills in their leadership positions? The findings from the in-depth interviews revealed two themes:

- Theme 1: Technical background can be utilized without involvement in technical details.
- Theme 2: Technical background can be utilized to solve problems and provide technical direction.

The two themes were based on four sub-themes, which will be discussed in the following sections.

Sub-theme 1: Using a technical base. Engineering leaders described how they utilized their background in technology and software engineering as a basis for leading within their organizations. The engineering leaders noted the importance of understanding the technical aspects of software engineering but emphasized that they utilized it to manage the organization instead of being directly involved in the details of producing technical outputs. For example, six of the engineering leaders discussed how they leverage their technical base to mentor and coach their teams but did not need to be the technical expert on a team. In addition to using their technical base to guide their teams, engineering leaders described how their technical base was important for building relationships within the organization. The engineering leaders felt their technical base gave them credibility with others in the organization, which established trust and respect.

For instance, one leader described the ability to translate technical information to wording that non-technical people could understand as a key skill that stemmed from having a strong technical base. These findings supported previous research by Kalliamvakou et al. (2017) who described how engineering leaders use their technical skills to help facilitate growth and discussion within the organization.

Kalliamvakou et al. (2017) had concluded that engineering leaders need a sufficient level of technical skills, but not necessarily excellence in each skill. The findings from this study were in agreement with Kalliamvakou et al. (2017) in regard to the level of technical skills needed in engineering leadership. Rottmann et al. (2015) described the importance of technical mastery in engineering leadership, such as being a subject matter expert and possessing the ability to engage in technical problem-solving. Based on the responses from software engineering leaders in this study, having a technical base was valuable for technical problem-solving, but being the expert was not seen as a critical factor in leading the organization.

Sub-theme 2: Transitioning away from details. The second sub-theme identified by the researcher answered the research question regarding the utilization of technical skills by showing how leaders' technical skills changed as they moved from individual contributor roles to leadership roles. Eleven of the 14 respondents from the in-depth interviews described how they moved away from the technical details as they transitioned into leadership positions. Some leaders noted how their technical expertise got in their way as a leader because they still wanted to be involved in the details and solve the problems for their teams. Thus, instead of having the detailed technical skills to perform software engineering tasks, the leaders indicated it was more important to move away from the technical details and transition to a skill set more involved with enabling and supporting their teams. For example, engineering leaders described their reliance on subject matter experts within the team to help understand how things work, instead of figuring it out themselves.

Leaders also cautioned about the risks involved in staying in the technical details when moving into leadership roles, such as not focusing on building other leadership skills such as human skills. One leader suggested delegation as an important skill to help transition out of the technical details and move into a leadership role. In general, while the engineering leaders enjoyed the technical aspects of software engineering, they realized the importance of getting out of the technical details and focusing on using their technical base to help drive the organization. These findings were similar to findings discussed by Kalliamvakou et al. (2017), regarding the risk of burnout and lack of team growth when engineering leaders stay involved in the technical details.

Sub-theme 3: Setting high-level technical direction. This sub-theme helped answer the first research question by describing the skills used to set high-level technical direction within the organization. The engineering leaders identified guiding and coordinating as key skills to help drive the technical direction. Facilitation skills were discussed from various angles by the engineering leaders as a way to guide the organization. For example, one leader described the ability to help team members focus on solving the problem by driving the discussion to get away from analysis paralysis, helping the team get beyond identifying the problem so team members can transition to generating possible solutions. Similarly, another leader mentioned guiding the conversation to help the team analyze the problem.

In addition to guiding and coordinating skills within their teams, leaders discussed using facilitation skills to help drive technical direction across teams and throughout the organization. For instance, taking a more hands-off approach by gathering the people who have the expertise together and allowing them to solve problems. The ability to identify the right people to solve the problem was discussed numerous times throughout the in-depth interviews.

While the engineering leaders agreed that helping drive technical direction was an important skill, this skill was used differently at different levels within the organization. For example, middle level engineering leaders were more focused on driving technical direction within their teams or with another team, compared to senior level engineering leaders who drove technical direction across the whole organization. While engineering leaders drove the technical direction from different perspectives, based on their roles within the organization, these skills were always an important part of their jobs as leaders.

The use of technical skills to set high level technical direction is contradictory to Katz's (1955) initial claims that technical skills are not as important in higher level managerial roles. While the engineering leaders felt that they did not need to be the technical experts, they did feel a technical base was important at all levels of management within software engineering leadership. This finding was more in line with Katz's (2009) revised claim, that technical skills are used at all levels within leadership positions.

Sub-theme 4: Problem-solving skills. Similar to the use of guiding and coordinating skills to drive technical direction, engineering leaders used a variety of problem-solving skills based on their level of leadership. For example, senior level engineering leaders' problem-solving skills were based on seeing patterns across the organization, whereas middle-level engineering leaders worked directly with their teams to help resolve problems. The engineering leaders described how problem-solving skills consist of the ability to ask the right questions based on their technical background. For example, engineering leaders described how they asked open-ended questions to help their teams think through all the implications of a potential technical solution.

Being able to understand the problem from a business perspective and solve it from an engineering perspective was a key skill identified by the engineering leaders. For example, one engineering leader discussed the ability to see the big picture and then asking questions that elicit a technical response as valuable in problem-solving. This skill connects technical and conceptual skills and corresponds to Katz's (1955) theory that technical and conceptual skills can stand alone but are also interrelated. The engineering leaders agreed that the ability for an engineering leader to have enough technical background to help drive problem resolution and communicate the problem was a critical skill. The problem-solving skills as discussed by the engineering leaders within the study aligned with the concepts described by Rottmann et al. (2015), regarding the ability to translate complex concepts to others within an organization.

To summarize the answer to research question one regarding engineering leaders' utilization of technical skills, leaders felt that having a technical background was important to help drive technical direction and problem-solving. It is also valuable to note that while technical background was important, staying out of the day-to-day application of technical details was also important. The engineering leaders noted how a technical background gave them credibility and can be used with skills such as guiding, coordinating, problem-solving, and communication to help connect business problems to technical solutions. Thus, it is important for upcoming engineering leaders to utilize their technical background, but understand they no longer need to be the technical expert. Upcoming engineering leaders need to develop their technical skills and also consider honing their human and conceptual skills to be capable of driving a business in the right technical direction.

Research Question 2. How do engineering leaders describe the utilization of human skills in their leadership positions? The findings of the in-depth interviews revealed two themes:

- Theme 3: Emotional intelligence skills are utilized to manage social awareness, self-awareness, and self-management.
- Theme 4: Relationship management skills are utilized for effective communication and interaction with others.

The first theme is focused on the concept of emotional intelligence (Goleman, 2000) as discussed in the literature review of human skills. Although none of the participants in the research study explicitly used the words emotional intelligence, the explanations and examples they used to describe their utilization of human skills fit into the concepts of emotional intelligence as described by Goleman (2000). The second theme, which focused on relationship management, was seen across the responses in all three areas of skills, technical, human, and conceptual. Relationship management as described by Goleman et al. (2013) was briefly discussed in the literature review and became a prevalent theme when analyzing the results of the study. The two themes were based on four sub-themes, which will be discussed in the following sections.

Sub-theme 1: Self-awareness. This sub-theme helped answer the research question on utilization of human skills by describing the value of having self-awareness in engineering leadership positions. When discussing human skills with the participants, numerous skills surfaced that related to self-awareness. Goleman (2000) described self-awareness as the ability to understand your own emotions and how they impact others. The engineering leaders highlighted skills such as knowing yourself, being aware when you are wrong, and being true to yourself. For example, Participant 5 pointed out how challenging it was to reflect on your own words and actions, but indicated it was important because no one wants to work with a brilliant jerk.

Having the ability to be aware when you are in the wrong and be true to yourself ties closely with the concept of human skills. Katz (1955) touched on the skill as self-awareness when describing how leaders need to be sensitive to the emotions of others within the organization and be your true self on a daily basis. The importance of this skill was not only called out in the interviews, but also surfaced as the top-rated skill in the Northouse Skills Inventory Surveys (2018). While the skills pertaining to self-awareness were a significant finding within this study, self-awareness skills were not mentioned as engineering leadership skills in previous research (Medcof, 2017; Rottmann et al., 2016). A unique finding in this dissertation study is that the skills regarding self-awareness should be included in engineering leadership.

Sub-theme 2: Self-management. In addition to the skill of self-awareness, the skill of self-management, the ability to control emotions, emerged from the data in this study when discussing the utilization of human skills. This sub-theme helped answer the research question by describing the skills used by engineering leaders to manage themselves, especially in stressful situations. Concepts such as the ability to listen, stay in the moment, control frustrations, and maintaining self-control to be calm, cool, and collected during stressful situations were key findings when discussing human skills.

Two specific findings came out of the analysis of skills related to self-management. Goleman (2000) identified self-control as a key skill within the broader area of self-management. The first finding showed the importance of self-control in engineering leadership positions. All the engineering leaders who participated in the study said that self-control was important, but many indicated it was a hard skill to master. The engineering leaders described situations where they needed to stay calm, cool, and collected when dealing with stressful situations. For example, participant 7 noted how the lack of self-control can lead to losing relationships within the organization and can create a perception of poor leadership ability.

The second key finding was the overuse of self-control. Three of the participants from the interviews pointed out that overuse of self-control can be detrimental to engineering leadership. For example, if engineering leaders hold back emotions, they may not have an impact on the team. Participant 13 described this as being monochromatic, which can be seen as not being engaged, not caring, or not being passionate about the work to be accomplished. Goleman (2000) discussed the value of self-control to manage disruptive emotions but noted that overuse of this skill can show lack of passion. The engineering leaders in this study agreed with this concept and were quick to note that there is a fine line between using self-control and appearing to be disengaged or disinterested. The engineering leaders described maintaining the subtle balance of self-control as a key skill.

Similar to the skill of self-awareness, the skill of self-management and specifically the skill of how to balance self-control was lacking in previous studies on engineering leadership (Kalliamvakou et al., 2017; Medcof, 2017; Rottmann et al., 2015). Based on the feedback from the participants in this study, self-management was an important skill within the area of human skills for engineering leaders.

Sub-theme 3: Social awareness. The third sub-theme that was uncovered when discussing human skills with participants was the ability to be socially aware. This sub-theme helped answer the research question by describing the skills used by engineering leaders when working with others in the organization. Goleman (2000) noted that social awareness was not about just being friendly, it was about using a friendly demeanor to get work completed to meet the goals of the organization. The skills that emerged from the data included the ability to be persuasive, have empathy, have influence, understand how to navigate politics, understand people by reading the room, and interpreting personalities.

Participants described the importance of having empathy for others in relation to social awareness because it is hard to understand the reactions of others unless you can put yourself in their shoes. The engineering leaders discussed how empathy with customers, employees, and peers was an important skill to master to understand how to work with people. Kalliamvakou et al. (2017) briefly touched on empathy when discussing relationships between engineering managers and employees but did not associate it with social awareness or emotional intelligence. The ability to be empathetic was not discussed in previous engineering leadership research, such as Rottmann et al. (2016) and Racine (2015). While empathy had not been prevalent in engineering leadership research, it did emerge as a key finding in this study, with many of the leaders commenting that they used empathy on a daily basis.

During the interviews, discussions about having empathy led to discussions about the ability to understand people. The engineering leaders described how they gained empathy by reading people's body language, listening, and reading reactions. Some engineers commented that they did not put much effort into understanding people until they moved into leadership positions. The engineering leaders discussed how most of their focus was on the technical aspects of the job when they were individual contributors and wished they had been given more training on social aspects before being moved into leadership positions.

The last skill in the context of social awareness was the ability to navigate politics within the organization. Engineering leaders are often put into positions where they have to balance the demands of the business and the needs of their teams. Many of the engineering leaders described the challenge of learning to navigate politics and indicated they spend a lot of time improving this skill. As Participant Five put it, gaining influence in the organization is a direct outcome of having strong social awareness skills such as the ability to read a room and understand everyone. Thus, an important outcome of the research was the need to train upcoming engineering leaders in social skills before moving into leadership roles, and then provide on-going training to continue improving these skills.

Sub-theme 4: Relationship management. The final sub-theme that developed from the data was centered around relationship management. This sub-theme helped answer the research question pertaining to the utilization of human skills by describing the importance of interaction, communication, and relationship building in an engineering leadership role. Goleman et al. (2013) noted the importance of the ability to manage relationships yet indicated that many leaders do not have this skill. Relationship management consists of the ability to interact with others and build personal bonds (Goleman et al., 2013).

The concept of relationship management surfaced in every aspect of the research in this study. For example, when discussing technical skills, engineering leaders described using their technical base to build relationships within their teams. Relationship management was also prevalent in the discussion of conceptual skills when describing critical thinking skills and working with people across the organization. During the human skills portion of the interviews, relationship management was a culmination of the ability to interact with others, implement strong communication skills, and build relationships.

Relationship management has been discussed in numerous studies on engineering leadership. For example, Rottmann et al. (2015) described the concept of collaborative optimization which encompassed skills such as the ability to build high performing teams and build bridges across the organization. Kalliamvakou et al. (2017) found that relationship building was a key attribute in engineering leadership, yet it was often overlooked. The engineering leaders within this study discussed the value of relationship building, not only within their teams but across the organization. Having the ability to build relationships was a key component when describing how work gets done. The engineering leaders stressed the importance of building relationships within the team to understand what motivates employees, build relationships with peers to gain buy-in and exchange work efforts, and build relationships with stakeholders to manage priorities and deliver results.

In addition to building relationships, having strong communication skills was identified as an important skill utilized by the engineering leaders in this study. Similar to the ability to build relationships, engineering leaders need to communicate with others who are within their teams, their peers, their stakeholders, and their managers. The need for engineering leaders to have strong communication skills is not a new discovery. Communication skills have been discussed in numerous studies on leadership in general and in studies pertaining specifically to engineering leaders (Boyatzis et al., 2017; Hartmann & Jahren, 2015; Hendon et al., 2017; Matturro et al., 2015; Minh et al., 2017; Racine, 2015). Communication skills are multi-faceted and complex, which could be seen by the variety of perspectives from each engineering leader.

No matter which area of skills was being discussed (technical, human, or conceptual) the ability to communicate continued to surface within the interview responses as critical to achieving success as an engineering leader. It is important to note that there was some discrepancy between the interview responses on communication and the Northouse Skills Inventory Survey (2018) statement number two. Statement two in the Northouse Skills Inventory Survey (2018) asked respondents to rank the following: "My main concern is to have a supportive communication climate." Out of the 23 responses in the survey, only 52.17% indicated this was *very true*. The complexity around communication skills may have led to this discrepancy, which could show the need for additional research in this area.

The last area of focus regarding relationship management that surfaced in the study was the ability to interact with others. There was some overlap with communication skills here, but some additional skills emerged from the data. For example, engineering leaders discussed the utilization of conflict resolution skills, not only within their teams but with other teams within the organization. The engineering leaders noted how conflict resolution skills were paired with other skills such as empathy, understanding personalities, and listening skills. Similar to communication skills, conflict resolution skills had also been identified in previous engineering leadership studies (Boyatzis et al., 2017; Cetindamar et al., 2016; Kalliamvakou et al., 2017; Paul & Falls, 2015; Rottmann et al., 2016) and thus was not a new finding but reiterated the importance of this skill in engineering leadership.

One additional key concept from the category of ability to interact with others was collaboration skills. Numerous engineering leaders identified collaboration as one of the most important skills utilized by engineering leaders. The skill of collaboration is tightly coupled with building relationships, but the engineering leaders described it as a culmination of many skills. For instance, one participant explained that collaboration helped when setting expectations and staying on the same page with everyone in the organization. Engineering leaders at every career level (managers to vice presidents) described the importance of partnering with others. This is especially the case within software engineering where there are numerous teams, working with different software applications, and members of those teams must talk to each other.

Collaboration has also become an important skill in engineering leadership due to the global economy. Cetindamar et al. (2016) touched on the importance of collaboration, especially in the global business world, where teams must learn to coordinate work across cultures. The findings in this study built on that idea as engineering leaders described the importance of gaining knowledge from people with a variety of backgrounds and people of different genders, races, and ages. Rottmann et al. (2015) identified collaborative optimization as a key finding in their research. The findings in this study supported the findings by Rottmann et al. (2015), based on the interconnectivity of systems within the engineering discipline, and thus the need for leaders to be able to work effectively across teams.

Overall, the utilization of human skills became a very in-depth and significant focal point in the findings within this study. While Katz (1955) indicated that human skills were valuable for all levels of management, this study took it one step further by making the connection with Goleman’s (2000) concepts of emotional intelligence and relationship management (Goleman et al., 2013). Human skills were discussed at length during the specific questions related to human skills but mention of human skills also permeated the responses in technical and conceptual skills. Thus, human skills emerged as the most important skills utilized by engineering leaders.

Research Question 3. How do engineering leaders describe the utilization of conceptual skills in their leadership positions? The findings from the Northouse Skills Inventory Survey (2018) and in-depth interviews revealed two themes:

- Theme 5: Seeing the big picture based on strategic and critical thinking skills can be utilized to solve problems and drive direction.
- Theme 6: Encouraging innovation through the ability to create fortuitous interactions and understand the business.

The two themes were based on four sub-themes, which will be discussed in the following sections.

Sub-theme 1: Critical thinking skills. This sub-theme addressed the utilization of conceptual skills research question by describing how engineering leaders utilize critical thinking skills to help solve problems and drive direction within the organization. During the interviews, the engineering leaders described a variety of skills that they associated with critical thinking, such as knowing the right questions to ask and helping the team solve problems. One of the key findings was the ability to utilize these critical thinking skills from a big picture thinking perspective to help drive the right solution for an organization.

While many of the existing research studies on engineering leadership did not identify critical thinking as a specific skill (Kalliamvakou et al., 2017; Kappelman et al., 2016; Racine, 2015), some researchers described similar aspects of critical thinking (Rottmann et al., 2015). For example, Rottmann et al. (2015) touched on similar skills such as big picture thinking, thinking outside the box, and posing problems under the theme of organizational innovation. The information uncovered in this study supported the skills identified by Rottmann et al. (2015) and added to the body of knowledge by providing a more in-depth perspective on how software engineering leaders utilize critical thinking skills.

Sub-theme 2: Strategic thinking skills. This sub-theme addressed the research question regarding the utilization of conceptual skills by showing how engineering leaders recognized the importance of driving the direction of the organization. Katz (1955) described the importance of leaders having conceptual skills such as the ability to understand where the organization needs to go and then guiding the team to get there. This concept could be seen in the responses from interview participants such as continuously looking across the organization to improve efficiencies (Participant 2) and having the ability to anticipate where the organization needs to go to continue to be successful (Participant 7).

A key finding from the interviews was the perception by many of the engineering leaders that strategic thinking skills are challenging for people who transition into engineering leadership positions. An example of this would be getting too involved in the day-to-day tasks for deliverables instead of looking forward to what needs to be done in the future. The engineering leaders who were in top management roles, such as Vice Presidents, were much more aware of the value of this skill, which aligns with Katz's (1955) claim that conceptual skills were more prevalent in high level managerial roles.

Sub-theme 3: Ability to encourage innovation. Katz (1955) did not discuss innovation in his initial research on conceptual skills. More recently, innovation has been a consideration because the concept of innovation has gained momentum with the rise of information technology (Silva & Di Serio, 2016). Innovation was prevalent in the findings by Rottmann et al. (2015, 2016) where skills such as operationalizing innovative ideas surfaced as part of engineering leadership. Based on existing literature (Rottmann et al., 2016), innovation was included in the research questions and uncovered information on how engineering leaders utilized their ability to encourage innovation within their organizations.

Two key findings surfaced from the discussions about encouraging innovation. The first finding was related to the importance of balancing innovation with the needs of the business. In other words, not innovating only for innovation's sake. Instead, engineering leaders discussed the importance of guiding teams to innovate but ground innovations in reality, to improve the organization.

The second key finding was the idea of creating fortuitous interactions. The idea behind this skill set is to think about how to get people in the organization to interact with each other on a regular basis. Participant 5 described the value of creating fortuitous interactions (providing opportunities for interactions to occur by chance rather than by being planned), because it creates an environment where people can freely share ideas and are more aware of projects that are being worked on within the organization.

Sub-theme 4: Business acumen. The sub-theme of having business acumen, the ability to understand the business aspects of the organization, answered the research question regarding conceptual skills by describing the importance of understanding how the business works in order to determine the right direction for the organization. Participant 5 described understanding how the business works, such as how the way a company makes money and spends money, are key to having influence as an engineering leader.

Kalliamvakou et al. (2017) touched on the idea of understanding the intent of the business, to help drive alignment in the organization. Rottmann et al. (2015) described the ability to be market savvy within the dimension of organizational innovation. Both of these concepts fit within the findings of this study. The findings from this study take it a step farther by suggesting the value of a deeper understanding of how a business functions, from a holistic perspective, can be an important skill for engineering leaders.

This is especially critical in high level leadership roles, where influence is also a key skill.

Overall, the four sub-themes regarding critical thinking skills, strategic thinking skills, encouraging innovation, and having business acumen drove the creation of the two themes for how engineering leaders utilize conceptual skills in their engineering leadership positions. Out of the three skills (technical, human, and conceptual) as defined by Katz (1955), conceptual skills ranked lower than technical skills and human skills in both the Northouse Skills Inventory Surveys (2018) and in the interviews.

When looking holistically across the whole study, the participants indicated that human skills were the most important skills needed in engineering leadership. While technical skills were considered important, they were seen as more of a foundation for engineering leadership. Similarly, conceptual skills were seen as valuable, but not used as much as human skills. Human skills, including emotional intelligence and relationship management emerged as the key skills needed in engineering leadership. Many of the participants indicated the technical skills came easy to them, yet the human skills were harder to grasp and implement when moving into engineering leadership positions.

The researcher's findings from this study described the utilization of technical, human, and conceptual skills by engineering leaders from a real-world perspective through the lens of Katz's (1955) three skills model. While some of the skills identified in this study re-iterated the results found in other studies (Kalliamvakou et al., 2017; Rottmann et al., 2015, 2016), new ideas emerged on the skills needed for engineering leadership. For example, the aspects of emotional intelligence (social awareness, self-awareness, self-management, and relationship management) were a key finding in this study that added to the body of knowledge in engineering leadership. In addition, the study supported the updated ideas from Katz (2009) that leaders need to have some aspect of technical, human, and conceptual skills at all levels of leadership. The findings of this study showed that engineering leaders felt all three skills (technical, human, and conceptual) contributed to their success as engineering leaders. The key is understanding how to utilize these skills when transitioning from an individual contributor role to an engineering leader position. The results of this study described how engineering leaders utilize these three skills to be effective in their leadership positions.

Implications

The purpose of this qualitative descriptive research study was to explore how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions within the information technology field in the United States. The study was based on the theoretical foundation of Katz's (1955) three skills model for effective leadership and results of this research study were reviewed from that theoretical perspective. The implications from a practical perspective show the connection to existing research on engineering leadership and provide new insights into how the knowledge gained within this study can improve engineering leadership. Finally, the strengths of the study show the credibility of the findings based on the methodology, design, data analysis, and results. The weaknesses will also be addressed to show the limitations within the study.

Theoretical implications. The three research questions that guided this study were directly aligned with Katz's (1955) three skills model which included technical skills, human skills, and conceptual skills. The research questions were: (R1) How do engineering leaders describe the utilization of technical skills in their leadership positions? (R2) How do engineering leaders describe the utilization of human skills in their leadership positions? (R3) How do engineering leaders describe the utilization of conceptual skills in their leadership positions? Based on these research questions, the data were gathered using the Northouse Skills Inventory Survey (2018) and in-depth interviews with software engineering leaders in the information technology field in the United States.

Katz (1955) asserted that leaders utilize technical skills (proficiency within a specific discipline), human skills (the ability to work with others), and conceptual skills (seeing the whole organization) in leadership positions. In his seminal article, Katz (1955) claimed that lower level managers use more technical skills, higher level managers use more conceptual skills, and all managers use human skills. In 2009, Katz updated his theory to indicate that the three skills were used equally across all levels of leadership.

When looking at the findings of this study in relation to the Katz (1955) theory and Katz's (2009) theory as revised decades later, there was evidence to support the more current findings by Katz. For example, the findings from this study were more in line with the updated version of Katz's (2009) theory because the findings indicated technical skills were utilized at all levels of engineering leadership, but only as a technical base. In other words, the engineering leaders felt that technical skills were valuable as a technical base but not to the extent that would be required of the technical experts on a team. The engineering leaders indicated that too much use of their technical skills while in a leadership role resulted in too much attention to non-managerial details that proved distracting and got in the way of their ability to lead an organization. One key addition from this study was that technical skills for engineering leaders were best utilized as a technical base to lead organizations.

Katz (1955, 2009) did not change his stance on the use of human skills in leadership positions across the decades, staying with the premise that human skills are used at all levels of leadership. That theory was found to be accurate in this study. Human skills were also found to have implications across all the skills discussed in the interviews. For instance, human skills were discussed as part of technical skills in relation to building relationships using a technical base. In addition, human skills were seen in discussions about conceptual skills such as critical thinking.

Although Katz (1955, 2009) indicated that human skills were utilized at every leadership level, the findings in this study supported that premise and also added to this concept, by showing how human skills were utilized more than technical and conceptual skills. Additionally, the researcher in this study made a connection between Katz's (1955, 2009) three skills theory and the theories of emotional intelligence as identified by Goleman (2000) and relationship management as identified by Goleman et al. (2013). These connections also add to the body of knowledge on the importance of human skills, specifically emotional intelligence and relationship management in engineering leadership.

In 2009, Katz changed his stance on the utilization of conceptual skills by indicating these skills were used across all levels of leadership, not just in upper level leadership positions. The findings in this study supported the finding by Katz (2009) in relation to middle and upper level software engineering leaders. Lower level (supervisory) leaders were not included in the sample of the study, so could not be considered in the implications of the research. Although Katz (2009) and this study supported the idea that conceptual skills were utilized by middle and upper level leaders, this study showed that conceptual skills were the least utilized skill by software engineering leaders. The research showed that engineering leaders felt conceptual skills such as critical thinking, strategic thinking, and encouraging innovation were important skills, but they were not used as much as human skills and technical skills. Participants indicated the use of conceptual skills was an area that they could improve on when carrying out their engineering leadership responsibilities.

Overall, the findings of this study were more in alignment with Katz's (2009) updates to his three-skills leadership theory than his original work (Katz, 1955). In additional to supporting Katz (2009), this study added to the concept of the three skills for effective leadership by specifying the optimal level of technical skills to be utilized by engineering leaders, making a connection to emotional intelligence (Goleman, 2000), making a connection to relationship management (Goleman et al., 2013), and indicating how conceptual skills were the least utilized skills by engineering leaders. The findings within this study added to the body of knowledge on engineering leadership, through the lens of Katz's (1955, 2009) three skills models, by uncovering additional findings that can be applied to the ongoing discussion about engineering leadership.

Practical implications. The practical implications based on the findings of this study can help organizations develop upcoming software engineering leaders by using the information gleaned in this study to improve leadership training for upcoming and existing engineering leaders. The following is a list of skills to consider when developing leadership programs for engineering leaders based on the findings from this study:

1. Technical skills. As people move from individual contributor roles to leadership roles, it is important to understand how to move away from personally handling all the technical details by teaching facilitation and delegation skills.

2. Human skills. Conducting courses on emotional intelligence may assist existing and upcoming engineering leaders in learning to work on self-awareness, self-management, social awareness, and relationship management skills.

3. Conceptual skills. Bring an awareness to upcoming and existing engineering leaders on the value of seeing the big picture and asking the right questions when solving problems. More specifically, this could be done by increasing connectivity to the rest of the organization by improving software engineering leaders' understanding of business functions within organizations.

Focusing on these areas of skills improvement may help upcoming leaders be more prepared for engineering leadership positions. Broy (2018) noted the importance of ongoing education for engineering leaders. Ongoing leadership courses for existing engineering leaders could also benefit the organizations in which leaders work.

In additional to engineering leadership program development within organizations, universities could also benefit from courses focused on skills beyond just teaching technical skills. As noted by the participants in this study, who have majored in technology-related fields, the technical concepts tend to come easily to them, yet they struggle with the human and conceptual skills. Adding course work that expands on their technical skills by adding human and conceptual skills may result in more well-rounded graduates who would be more desirable and successful in the workforce.

Future implications. This study brought new insights in engineering leadership through the lens of the Katz (1955, 2009) three skills models of leadership, in addition to validating many findings of previous researchers (Kalliamvakou et al., 2017; Rottmann et al., 2016). New insights were uncovered in relation to the concepts of emotional intelligence and relationship management (Goleman, 2000; Goleman et al., 2013) as well as the need to bring more awareness to the utilization of human and conceptual skills, which furthers the discussion on engineering leadership.

Based on the findings in this study, organizations could adjust their engineering leadership training programs to incorporate more focus on human skills ,such as emotional intelligence and relationship management (Goleman, 2000; Goleman et al., 2013) to help improve engineering leadership. Carfagno (2017) indicated the importance of developing comprehensive leadership skills within engineering degrees, but noted it was challenging due to the demands of developing specific technical skills. Although it would be challenging, it may be worthwhile for universities to consider how to make changes to curriculum to include the development of human and conceptual skills in additional to developing students' technical skills.

Strengths and weaknesses of the study. Prior to this study, there was limited data on engineering leadership skills from real-world software engineering leaders in the information technology field in the United States (Kalliamvakou et al., 2017). As noted by Boyatzis et al. (2017), there are many time-sensitive demands within the engineering world. As a result, it can be challenging to persuade engineering leaders to participate in a qualitative research study. One of the strengths of this study was the fact that the researcher was able to recruit 23 engineering leaders to complete the Northouse Skills Inventory Survey (2018) and 14 engineering leaders to participate in individual interviews. The 14 engineering leaders who participated in the individual interviews were engaged and passionate when talking about the skills they utilize in their engineering leadership positions. This passion and engagement led to robust interview responses which strengthened the results of the study with rich data.

Another strength of the study was the close connection of the results to preexisting theoretical research. This applies to the findings of the theoretical foundation of Katz's (1955, 2009) three skills model plus the additional connection to emotional intelligence (Goleman, 2000) and relationship management (Goleman et al., 2013). The combination of these theories in support of the findings of this study adds to the body of knowledge on engineering leadership.

All studies have limitations that need to be noted and this study was no exception. One of the weaknesses of the study was the novice experience of the researcher. While the robust responses from the in-depth interviews were a strength in this study, it also uncovered a weakness due to the researcher's lack of experience dealing with large amounts of data. The researcher worked to overcome this weakness by using tools such as MAXQDA and established thematic data analysis processes such as suggested by Braun and Clarke (2006).

An additional limitation was the connection that the researcher had with the participants due to recruitment from the researcher's LinkedIn account. While the researcher did not know all of the participants personally prior to the interviews, there were some participants who had prior professional connections with the researcher. This required the researcher to be extra diligent in sticking to the interview protocol and using reflexivity throughout the interviews.

Overall, this study provided credible conclusions due to the robust use of qualitative methodology via an inductive approach to gaining insights on the utilization of technical skills, human skills, and conceptual skills from software engineering leaders based on real-world experiences. In addition, the data analysis used a proven method of thematic analysis (Braun & Clarke, 2006) which included a step-by-step process to analyze the data provided in the interviews. The results were organized by research question based on the themes and sub-themes found in the data analysis. Following a robust process for data gathering and data analysis provided validity for the results and applications of this study.

Recommendations

This researcher explored how engineering leaders describe the utilization of human skills, technical skills, and conceptual skills in their leadership positions. The sample included engineering leaders from middle and higher-level leadership positions within the information technology field in the United States. While this study provided insight and added to the body of knowledge on engineering leadership, it also uncovered additional areas that could be researched to continue the discussion on engineering leadership.

Recommendations for future research. Ideas for additional research emerged, based on the results of this study. This research study considered the three skills of effective leadership as identified by Katz (1955, 2009) with a sample of engineering leaders who had been in a leadership position for at least two years in the information technology field. Based on the results of this study, certain concepts stood out as valuable insights that warrant further investigation.

Given the focus on all three skill sets, it may be beneficial for future research to focus on just one of the skillsets to get a more in-depth perspective. Emotional intelligence and relationship management emerged as important components in this study. Additional studies could delve deeper into the utilization of these and other human skills.

Within the findings on the utilization of human skills, there was a discrepancy between the Northouse Skills Inventory Survey (2018) results and the responses in the interview questions regarding the value of communication skills. For example, statement eight in the Northouse Skills Inventory Survey (2018) showed a wide range of responses to the importance of a supportive communication climate, yet the interviews identified communication as a key skill. Future studies could focus on the utilization of communication skills within software engineering leadership positions.

Finally, the current study had a narrow focus of engineering leaders within the information technology field with at least two years of experience. Broadening the sample to include other levels of engineering leaders or other leaders from other areas within information technology may be valuable. The following are recommendations for future research:

1. Conduct a qualitative research study with engineering leaders that is only focused on emotional intelligence and relationship management based on theories from Goleman (2000) and Goleman et al. (2013).

2. Conduct a quantitative research study with either upcoming or existing engineering leaders to determine their level of emotional intelligence before and after training on human skills.

3. Consider researching the utilization of communication skills in engineering leadership.

4. Consider the skills utilized by lower level engineering managers (supervisors with less than two years of experience in engineering leadership). The current study only considered middle and higher-level engineering leaders.

5. Consider the skills utilized by engineering leaders who do not have a technical background. All of the engineering leaders in the current study had a technical

background, so it would be worth exploring the perceptions of engineering leaders who did not rise up through the technical ranks within software engineering.

6. Consider the skills utilized by engineering leaders from other disciplines within information technology such as Operations, Program Management, Project Management, Quality Assurance, and Support.

Recommendations for future practice. The field of information technology continues to grow, and engineering leaders play a key role in helping organizations be successful (Perri et al., 2019). Based on the need for engineering leaders, this study was focused on the need to explore how engineering leaders described the utilization of skills in their leadership positions. The findings in this study provided new insights into the skills utilized by engineering leaders within the information technology field in the United States. The study not only advanced the discussion on engineering leadership, but also provided insights into the challenges that engineering leaders faced when transitioning into leadership positions and the skills they use in leadership positions. These insights can be valuable to help engineering leaders be more effective in their leadership positions, as well as help upcoming engineering leaders gain an understanding of the skills they will need in leadership positions. As Medcof (2017) noted, there is a lack of leadership development within technology-oriented organizations, thus the findings in this study may be valuable to improve engineering leadership training in these fields. The researcher provided the following list of recommendations for future practice by implementing training programs based on the results of this study:

1. ***How to utilize a technical base without being in the details***. As people transition from individual contributor roles to leadership roles, they have a technical base in software engineering, but may struggle to transition away from the technical details and move into a broader leadership position. It is important for engineering leaders to find the balance of keeping up with technology trends but move away from the technical details. Training on skills such as facilitation and delegation may help upcoming engineering leaders understand their new role and gain a

perspective on the level of technical detail needed in an engineering leadership position.

2. ***How to utilize a technical base to solve problems and provide technical direction.*** Engineering leaders noted how it was important to help the team solve problems and to provide technical direction in an engineering leadership position. This involved the ability to ask the right questions, getting the right people in the room, and being able to understand the business impact of technical decisions. While some of these skills may be learned on the job, they could be enhanced or accelerated by providing specific training classes focused on business acumen. In other words, learning how the business functions, understanding business terminology, and understanding how all the systems relate within the organization may help engineering leaders with problem-solving and driving technical direction.

3. ***Learning and applying emotional intelligence skills***. In addition to teaching engineering leaders about the right level of technical skills, there needs to be a focus on teaching human skills, such as emotional intelligence. Based on the in-depth responses in the interviews in this study, skills such as self-awareness, self-management, and social awareness surfaced as key skills needed in engineering leadership. While emotional intelligence was not explicitly used by any of the participants, the responses fit into the skills of emotional intelligence defined by Goleman (2000). Participant 5 provided a straightforward response to the importance of emotional intelligence by saying no one wants to work with a brilliant jerk. Training on emotional intelligence skills and subsequent application of these skills can be valuable in improving the overall skills of the engineering leaders.

4. ***Learning and applying relationship management skills.*** Relationship management skills also surfaced as a key skill that engineering leaders used in conjunction with everything they did on a daily basis. For example, relationship management was used with the engineering leader's technical base to build relationships within their teams. Engineering leaders also mentioned relationship management as important to build relationships across the organization with peers and stakeholders using communication and collaboration skills. Training on how to improve these skills would be valuable for upcoming and existing engineering leaders. Based on the results of the study, the researcher also suggested establishing coaches or mentors as beneficial for application of relationship management skills on a daily basis.

5. ***How to see the big picture via critical thinking and strategic thinking.*** Similar to the utilization of a technical base to help drive the team in problem-solving, the results of this study indicated using critical skills and strategic thinking were a key part of engineering leadership. The engineering leaders in high level leadership positions were more in-tuned to the value of this skill. They indicated the value of looking forward instead of being in the day-to-day details. The engineering leaders also indicated the importance of seeing across the whole

organization to better understand the ripple effect of changes made within one area. Similar to the skills identified above, this skill could be learned from time spent on the job but could also be accelerated by providing engineering leaders an overview of the organization and the connection between systems.

6. ***Encouraging innovation***. The final area of focus within this study was looking at how innovation can be encouraged within the organization by engineering leaders. Silva and Di Serio (2016) indicated the importance of innovation to improve competitive advantage within an organization. Thus, it is important to consider how innovation can be successfully factored into the demands within software engineering. Engineering leaders described how they have needed to balance the needs of the business with the ability to be innovative. Engineering leaders indicated they encourage innovation, but within the context of solving business problems. The other key finding that surfaced in regard to innovation was the ability to create fortuitous interactions. In other words, creating situations where people come together by chance instead of planned or formal meetings. Training engineering leaders on ways they can encourage innovation while still balancing the needs of the business could go a long way in creating a competitive advantage in an organization. In addition, helping engineering leaders understand how to create fortuitous interactions may lead to improved communication and collaboration across the organization.

In summary, there are many aspects to the skills needed in engineering leadership. While engineering leaders may have a strong technical background based on formal training or hands on application, they do not always get the same level of skills training in human and conceptual skills. Improving human skills such as emotional intelligence and relationship management were identified by the engineering leaders in this study as key skills for engineering leadership within the information technology field. This ties back to the theoretical foundation from the Katz (1955, 2009) three skills model for leadership, and expands upon engineering leadership based on real-world perceptions from software engineering leaders.

In addition to improving human skills, this study uncovered conceptual skills were not utilized as much by engineering leaders, but still deemed important, especially when moving into higher level engineering leadership positions. Thus, additional focus on developing critical thinking, strategic thinking, encouraging innovation, and understanding business acumen could be valuable skills for engineering leaders. Engineering leaders play a key role in organizations, as seen in the results of this study, be being in a central position within the organization to drive technical results and achieve organizational objectives. Therefore, it is valuable to continuously improve engineering leadership skills within organizations.

References

AbuJbara, N., & Worley, J. (2018). Leading toward new horizons with soft skills. On the Horizon, 26(3), 247-259. doi: 10.1108/OTH-10-2017-0085

Beckhusen, J. (2016). *Occupations in information technology*. US Department of Commerce, Economics and Statistics Administration, US Census Bureau.

Birt, L., Scott, S., Cavers, D., Campbell, C., & Walter, F. (2016). Checking: A tool to enhance trustworthiness or merely a nod to validation? *Qualitative Health Research, 26*(13), 1802-1811.

Boyatzis, R., Rochford, K., & Cavanagh, K. V. (2017). Emotional intelligence and social intelligence competencies in engineer's effectiveness and engagement. *Career Development International*, *22*(1), 70-86.

Boyce, C., & Neale, P. (2006). Conducting in-depth interviews: A guide for designing and conducting in-depth interviews for evaluation input.

Bradshaw, C., Atkinson, S., & Doody, O. (2017). Employing a qualitative description approach in health care research. *Global Qualitative Nursing Research, 4*, 2333393617742282.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.

Broy, M. J. I. S. (2018). Yesterday, Today, and Tomorrow: 50 Years of Software Engineering. *35*(5), 38-43.

Bureau of Labor Statistics, U. S. Department of Labor, *Occupational Outlook Handbook*, Computer and Information Systems Managers. Retrieved from https://www.bls.gov/ooh/management/computer-and-information-systems-managers.htm

Capretz L., & Ahmed F. (2018). A call to promote soft skills in software engineering. *Psychol Cogn Sci Open J., 4*(1): e1-e3. doi: 10.17140/PCSOJ-4-e011

Carfagno, R. (2017). Engineering leadership programs in colleges and universities: a focus on morality. *The Journal of Values-Based Leadership, 10*(2), 6. doi:10.22543/0733.102.1186

Caruso, D. R., Bhalerao, H., & Karve, S. (2016). Special issue on emotional intelligence. *Business Perspectives and Research, 4*(1), ix-xii. doi:10.1177/2278533715609205

Castillo-Montoya, M. (2016). Preparing for interview research: the interview protocol refinement framework. *The Qualitative Report, 21*(5), 811-831.

Castleberry, A., & Nolen, A. (2018). Thematic analysis of qualitative research data: Is it as easy as it sounds? *Currents in Pharmacy Teaching and Learning, 10*(6), 807-815.

Cetindamar, D., Phaal, R., & Probert, D. (2016). Technology management as a profession and the challenges ahead. *Journal of Engineering and Technology Management, 41*, 1-13.

Colorafi, K., & Evans, B. (2016). Qualitative descriptive methods in health science research. *HERD: Health Environments Research & Design Journal, 9*(4), 16-25.

Cortada, J. W. (2017). A history of information in the United States since 1870. Information & Culture: A Journal of History, 52(1), 64-84. https://doi.org/10.1353/lac.2017.0002

Department of Health (2014). The Belmont Report. Ethical principles and guidelines for the protection of human subjects of research. *The Journal of the American College of Dentists, 81*(3), 4.

Elegbe, J. A. (2015). Emotional intelligence missing priority in engineering programs. *Journal of Business Studies Quarterly, 7*(2), 196-207.

Ellis, T. J., & Levy, Y. (2010). A guide for novice researchers: Design and development research methods. In *Proceedings of Informing Science & IT Education Conference (InSITE)* (Vol. 10, pp. 107-118).

Etikan, I., Musa, S., & Alkassim, R. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics, 5*(1),1-4. doi:10.11648/j.ajtas.20160501.11

Farr, J. V., Walesh, S. G., & Forsythe, G. B. (1997). Leadership development for engineering managers. *Journal of Management in Engineering, 13*(4), 38-41.

Fiedler, F. E. (1981). Leadership effectiveness. *The American Behavioral Scientist (Pre-1986), 24*(5), 619.

Gallipoli, G., & Makridis, C. (2018). Structural transformation and the rise of information technology. *Journal of Monetary Economics, 97,* 91-110.

[GCU IRB Webinar]. (2019, August 20). *Alignment and IRB Submissions* [Video file]. Retrieved from https://youtube.com/watch?v=IGjB63Vzcxo

Goleman, D. (2000). What Makes a Leader? *Harvard Business Review, 78*(2), 78-90.

Goleman, D., Boyatzis, R. E., & McKee, A. (2013). *Primal leadership: Unleashing the power of emotional intelligence*: Harvard Business Press.

Grand Canyon University. (2017). Dissertation template V8.3 01-18-18. Retrieved from https://dc.gcu.edu/dissertation/dissertation-templates/dissertation_template/dissertation_template_2017_v8_documents

Greenberger, S. (2015). Chapter 2 Foundations of Empirical Research [Supplemental material]. In *Foundations and Theories* (Chapter 2). Phoenix, AZ: Grand Canyon University. Retrieved from http://lc.gcumedia,com/res850/gcu-doctoral research-foundations-and-theories/v1.1/#/chapter/2

Grimm, B. L., Watanabe-Galloway, S., Britigan, D. H., & Schumaker, A. M. (2015). A qualitative analysis to determine the domains and skills necessary to lead in public health. *Journal of Leadership Studies, 8*(4), 19-26. doi:10.1002/jls.21342

Harrison, C., Burnard, K., & Paul, S. (2018). Entrepreneurial leadership in a developing economy: A skill-based analysis. *25*(3), 521-548.

Harrison, H., Birks, M., Franklin, R., & Mills, J. (2017). *Case study research: Foundations and methodological orientations.* [Paper presented at the Forum Qualitative Sozialforschung.]

Hartmann, B., & Jahren, C. (2015). Leadership: Industry needs for entry-level engineering positions. *Journal of STEM education*, *16*(3).

Hendon, M., Powell, L., & Wimmer, H. (2017). Emotional intelligence and communication levels in information technology professionals. *Computers in Human Behavior, 71*, 165-171. doi:10.1016/j.chb.2017.01.048

Hickman, L., & Akdere, M. (2017). Development of effective IT leadership behaviors: A review.

Hickman, L., & Akdere, M. (2018). Effective leadership development in information technology: building transformational and emergent leaders. *Industrial and Commercial Training, 50(1),* 1-9.

IEEE. (2017). International Standard: Systems and software engineering - vocabulary.

Kajornboon, A. B. (2005). Using interviews as research instruments. *E-journal for Research Teachers, 2*(1), 1-9.

Kalliamvakou, E., Bird, C., Zimmermann, T., Begel, A., DeLine, R., & German, D. (2017). What makes a great manager of software engineers? *IEEE Transactions on Software Engineering*.

Kappelman, L., Johnson, V., Maurer, C., McLean, E., Torres, R., David, A., & Nguyen, Q. J. M. Q. E. (2018). *The 2017 SIM IT Issues and Trends Study. 17*(1).

Kappelman, L., Jones, M. C., Johnson, V., McLean, E. R., & Boonme, K. (2016). Skills for success at different stages of an IT professional's career. *Communications of the ACM, 59*(8), 64-70. doi:doi:10.1145/2888391

Katz, R. (1955). Skills of an Effective Administrator. *Harvard Business Review, 33,* 33-42.

Katz, R. L. (2009). *Skills of an effective administrator*. Harvard Business Review Press.

Kearns, K. P., Livingston, J., Scherer, S., & McShane, L. (2015). Leadership skills as construed by nonprofit chief executives. *Leadership & Organization Development Journal, 36*(6), 712-727.

Lambert, V., & Lambert, C. (2012). Qualitative descriptive research: An acceptable design. *16*(4), 255-256.

LinkedIn Corporation (2019). *About Us*. Retrieved from https://news.linkedin.com/about-us#statistics

Lopes, D. C., Gerolamo, M. C., Del Prette, Z. A. P., Musetti, M. A., & Del Prette, A. (2015). Social Skills: A key factor for engineering students to develop interpersonal skills. *International Journal of Engineering Education, 31*(1), 405-413.

Lopes, P. N. (2016). Emotional intelligence in organizations: Bridging research and practice. *Emotion Review, 8*(4), 316-321. doi:10.1177/1754073916650496

Mahdavian, M., Wingreen, S., & Ghlichlee, B. (2016). The influence of key users' skills on ERP success. *27*(2), 48-64.

Mann, F. C. (1965). Toward an understanding of the leadership role in formal organizations. *Leadership and productivity*, 68-103.

Mason, M. (2010). Forum: Qualitative Social Research, Sample size and saturation in PhD studies using qualitative interviews. *DOI:10.17169/fqs-11.3, 1428*(11), 3.

Matteson, M., Anderson, L., & Boyden, C. (2016). " Soft Skills": A phrase in search of meaning. *16*(1), 71-88.

Matturro, G., Raschetti, F., & Fontán, C. (2015). Soft skills in software development teams: A survey of the points of view of team leaders and team members. In *Proceedings of the Eighth International Workshop on Cooperative and Human Aspects of Software Engineering* (pp. 101-104). IEEE Press.

Maurer, T. J., & London, M. (2015). From individual contributor to leader: A role identity shift framework for leader development within innovative organizations. *Journal of Management, 44*(4), 1426-1452. doi:10.1177/0149206315614372

Mayer, J., Caruso, D., & Salovey, P. (2016). The ability model of emotional intelligence and social intelligence: Principles and updates. *Emotion Review*, *8*(4), 290-300.

Medcof, J. W. (2017). Leadership development: Towards a more systematic approach in technology management. *The Journal of High Technology Management Research*, *28*(2), 167-178.

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative Research: A Guide to Design and Implementation* (Vol. Fourth edition). San Francisco, CA: Jossey-Bass. Retrieved from https://lopes.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=1022562&site=ehost-live&scope=site

Minh, N. V., Badir, Y. F., Quang, N. N., Afsar, B. J. J. o. E., & Management, T. (2017). The impact of leaders' technical competence on employees' innovation and learning. *44*, 44-57.

Moon, K., Brewer, T. D., Januchowski-Hartley, S. R., Adams, V. M., & Blackman, D. A.(2016). A guideline to improve qualitative social science publishing in ecology and conservation journals. *Ecology and Society, 21*(3), 133-152. doi:10.5751/ES-08663-210317

Mumford, M. D., Zaccaro, S. J., Harding, F. D., Jacobs, T. O., & Fleishman, E. A. J. T. L. Q. (2000). Leadership skills for a changing world: Solving complex social problems. *11*(1), 11-35.

Nix, S., & Bigham, G. (2015). Five critical skills necessary for the interim superintendent in Texas. *10*(2), 7.

Northouse, P. G. (2018). *Leadership: Theory and practice*: Sage publications.

Obradović, V., Montenegro, A., & Bjelica, D. (2018). Digital era and project manager's competencies.

Oliveira, M., Bitencourt, C., Zanardo dos Santos, A., & Teixeira, E. (2016). Thematic content analysis: Is there a difference between the support provided by the MAXqda® and Nvivo® software packages?. *Brazilian Journal of Management / UFSM Management Journal*, *9* (1), 72-82. doi: 10.5902 / 1983465911213

Paul, R., & Falls, L. (2015). Mapping career success competencies to engineering leadership capabilities. *Frontiers in Education Conference (FIE), 2015 IEEE,* 1-6. doi:10.1109/FIE.2015.7344401

Paul, R., Sen, A., & Wyatt, E. (2018). *Board 92: What is engineering leadership? A proposed definition.* Paper presented at the 2018 ASEE Annual Conference & Exposition.

Percy, W. H., Kostere, K., & Kostere, S. (2015). Generic qualitative research in psychology. *The Qualitative Report,20*(2), 76-85.

Perri, S. T., Farrington, T., Johnson, S., & O'Connor, G. C. (2019). Today's Innovation Leaders. *Research Technology Management, 62*(1).

Perry, S. J., Hunter, E. M., Currall, S. C., & Frauenheim, E. (2017). Developing engineering leaders: An organized innovation approach to engineering education. *Engineering Management Journal, 29*(2), 99-107. doi:10.1080/10429247.2017.1298189

Peterson, T. O., & Van Fleet, D. D. J. M. d. (2004). The ongoing legacy of RL Katz: An updated typology of management skills. *42*(10), 1297-1308.

Pons, D. J. (2015). Changing importances of professional practice competencies over an engineering career. *Journal of Engineering and Technology Management, 38*, 89-101. doi:10.1016/j.jengtecman.2015.10.001

Racine, W. P. (2015). Social identity development and the situation of scientists and engineers as new leaders. *Journal of Leadership Studies, 9*(3), 23-41. doi:10.1002/jls.21398

Rottmann, C., Reeve, D., Klassen, M., Kovalchuk, S., Liu, Q., Olechowski, A., & Santia, M. (2018). Examining the Engineering Leadership Literature: Community of Practice Style. *American Society for Engineering Education*.

Rottmann, C., Reeve, D., Sacks, R., & Klassen, M. (2016). An Intersubjective Analysis of Engineering Leadership across organizational locations: Implications for Higher Education. *The Canadian Journal of Higher Education, 46*(4), 146 - 173.

Rottmann, C., Sacks, R., & Reeve, D. (2015). Engineering leadership: Grounding leadership theory in engineers' professional identities. *Leadership, 11*(3), 351-373. doi: 10.1177/1742715014543581

Saldaña, J. (2015). *The coding manual for qualitative researchers*: Sage.

Salovey, P., & Mayer, J. D. (1990). Emotional intelligence and social intelligence. *Imagination, cognition and personality, 9*(3), 185-211.

Sandelowski, M. (2000). Whatever happened to qualitative description?. *Research in Nursing and Health, 23*(4), 334-340.

Sauro, J. (2015). 5 Types of Qualitative Methods. Retrieved from https://www.measuringu.com/blog/qual-methods.php

Schell, W., & Kauffmann, P. (2016). Understanding engineering leadership: a critical review of the literature. *Proceedings of the International Annual Conference of the American Society for Engineering Management, Huntsville: 1-11*.

Schmidt, W. (2018). GCU core research designs. Retrieved from https://dc.gcu.edu/documents/refereancestandards/2013-residency-2/2013-rsd-851/02_course_materials/rsd851r081_core_research_designspptx

Schmidt, W. (2018a). Nature of the research design for the study. Retrieved from https://dc.gcu.edu/documents/refereancestandards/2013-residency-2/2013-rsd-881/02_course_materials/6_nature_of_the_research_design_for_the_studypptx~1

Silva, G., & Di Serio, L. C. (2016). The sixth wave of innovation: Are we ready? RAI Revista de Administração e Inovação, 13, 128–134. https://doi.org/10.1016/j.rai.2016.03.005

Simmons, D. R., Clegorne, N. A., & Woods-Wells, T. (2017). Leadership paradigms in construction: critical review to inform research and practice. *Journal of Management in Engineering*, *33*(4). doi:10.1061/(asce)me.1943-5479.0000518

Stokes, Y., Vandyk, A., Squires, J., Jacob, J.-D., & Gifford, W. (2019). Using Facebook and LinkedIn to recruit nurses for an online survey. *Western Journal of Nursing Research*, *41*(1), 96-110.

Uhr, C. (2017). Leadership ideals as barriers for efficient collaboration during emergencies and disasters. *25*(4), 301-312.

Wang, Y.-Y., Lin, T.-C., & Tsay, C. H.-H. (2016). Encouraging IS developers to learn business skills: an examination of the MARS model. *Information Technology & People*, *29*(2), 381–418.

Williams, J. (2016, June). How IT leadership will change by 2020 and why it matters. In *Computer Software and Applications Conference (COMPSAC), 2016 IEEE 40th Annual* (Vol. 1, pp. 343-343). IEEE.

Yates, J., & Leggett, T. (2016). Qualitative research: An introduction. *Radiologic technology*, *88*(2), 225-231.

Yilmaz, K. (2013). Comparison of quantitative and qualitative research traditions: Epistemological, theoretical, and methodological differences. *European Journal of Education*, *48*(2), 311-325.

Yin, R. K. (2016). *Qualitative research from start to finish*. Guilford Publications.

Appendix A.

Site Authorization Letter

The proposed study will use a passive recruitment strategy by utilizing connections with participants via LinkedIn accounts. This does not require Site Authorization per GCU IRB Webinar (2019).

Appendix B.

IRB Approval Letter

GRAND CANYON
UNIVERSITY

3300 West Camelback Road, Phoenix Arizona 85017 602.639.7500 Toll-Free 800.800.9776 www.gcu.edu

DATE: January 27, 2020
TO: Merri Pedersen
FROM: Grand Canyon University Institutional Review Board
STUDY TITLE: Engineering Leaders'Descriptions of Leadership Competencies
IRB REFERENCE #: IRB-2019-1736
SUBMISSION TYPE: Amendment/Modification

ACTION: ACKNOWLEDGED

Thank you for submitting the Amendment/Modification materials for the above research study.

The Grand Canyon University Institutional Review Board has ACKNOWLEDGED your submission.

No further action on submission IRB-2019-1736 is required at this time.

The following items are acknowledged in this submission:

•

Submission Components

Form Name	Version	Outcome
GCU - IRB Modification Form	Version 1.1	Acknowledged
Revision Request Form	Version 2.0	Acknowledged
Revision Request Form	Version 1.0	Acknowledged

Study Document

Title	Version #	Version Date	Outcome
ConsentDocument-SurveyMonkey and Link to SurveyMonkey	Version 1.2	01/14/2020	Approved
Recruitment Attempts with the International Association of Innovation Professionals	Version 1.0	01/14/2020	Reviewed
Recruitment Script Template-pedersen	Version 1.0	01/14/2020	Reviewed
GCU M Pedersen proposal for IRB 01 07 2020	Version 1.0	01/14/2020	

You are now approved to collect data. If you have any questions, please contact the IRB office at irb@gcu.edu.

Please include your study title and reference number in all correspondence with this office.

Dr. Cynthia Bainbridge

Assistant Dean, Research and Dissertations
Director, Institutional Review Board
College of Doctoral Studies

Appendix C.

Informed Consent

INFORMED CONSENT FORM

INTRODUCTION

The title of this research study is, "Engineering Leaders' Descriptions of Leadership Competencies".

I am Merri Pedersen, a doctoral student under the supervision of Dr. Mary Selke in the College of Doctoral Studies at Grand Canyon University. The purpose of this study is to explore how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their leadership positions within the information technology field in the United States.

KEY INFORMATION

This document defines the terms and conditions for consenting to participate in this research study.

How do I know if I can be in this study?

1. You are currently in a middle or upper level engineering leadership position.
2. You have a LinkedIn account.
3. You have more than two years of leadership experience in the information technology field.
4. You reside in the United States.

You cannot participate in this study if:

1. You are not in a middle or upper level engineering leadership position.
2. You do not have a LinkedIn account.
3. You have less than two years of leadership experience in the information technology field.
4. You reside in another country outside the United States.

If you agree to be in this study, you will be asked to:

- ***What:*** Complete a Northouse Skills Inventory Survey (2018), participate in a 1:1 interview, and attend a follow-up meeting.
- ***When:*** Once you complete the Northouse Skills Inventory Survey (2018), I will schedule a time to meet for the in-depth interview.
- ***Where:*** The Northouse Skills Inventory Survey (2018) will be administered on-line via surveymonkey.com. The in-depth interview and follow up meeting will take place via video conference.
- ***How:*** The Northouse Skills Inventory Survey (2018) will take ~ 10 minutes via your computer, the 1:1 interview will take ~ 60 minutes via video conference, and the follow up meeting will take ~ 30 minutes via video conferencing.

  I would like to use a voice recorder to record your responses. You can still participate if you do not wish to be recorded. Your identity will be protected by removing your name from all devices and documents after the interview has been transferred into transcripts.

Who will have access to my information? Myself and my doctoral committee members: Dr. Mary Selke, Dr. Tianyi Zhang Ulyshen, and Dr. Mark Bouie.

Participation is voluntary. However, you can leave the study at any time, even if you have not finished, without any penalty or loss of benefits to which you are otherwise entitled. If you decide to stop participation, you may do so by emailing me to indicate you do not wish to continue with the study. If so, I will use the information I gathered from you.

- ***Any possible risks or discomforts?*** There are no foreseeable risks or discomforts associated with this study.
- ***Any direct benefits for me?*** I will provide the results at the conclusion of the study, which may provide additional insight into the utilization of skills in engineering leadership positions.
- ***Any paid compensation for my time?*** You will receive a $25 Amazon gift card if you complete the Northouse Skills Inventory Survey (2018), interview, and follow-up meeting. The gift cards will be distributed via email after the Northouse Skills Inventory Survey (2018), interviews, and follow-up meetings are completed.
  How will my information and/or identity be protected? I will not be able to link participant data back to individuals who participated in the study after the study is complete. I will de-identify the participant's names after transferring the information into data files. The data files will be maintained in a locked safe for three years. After the three years, if the data is deemed no longer needed, I will destroy the data.

PRESENTATION OF INFORMATION COLLECTED

I will present the data in both grouped results and individual results which will be published in the dissertation document. I may use the information in future publications and conferences.

PRIVACY AND DATA SECURITY

Will researchers ever be able to link my data/responses back to me? No, I will de-identify the data, so no participant names will appear in any of the documents.
Will my data include information that can identify me (names, addresses, etc.)? No, your name will be removed from all documents.
Will researchers assign my data/responses a research ID code to use instead of my name? Yes

- ***If yes, will researchers create a list to link names with their research ID codes?*** Yes, during the analysis of the data, I will create a list of names linked to research ID codes.
- ***If yes, how will researchers secure the link of names and research ID codes? How long will the link be kept? Who has access? Approximate destroy date?*** I will keep the link of names and research ID codes on my personal computer with password protection. The link will be kept for three years. If the data is deemed no longer needed, I will destroy the data. I am the only person who will have access to the data. The approximate destroy date is April 2023.

How will my data be protected (electronic and hardcopy)? Where? How long? Who will have access? Approximate destroy or de-identification date? The data will be protected on my personal computer with password protection. Hardcopies will be stored in a locked safe for three years. After the data is deemed no longer needed, I will destroy the data from the personal computer and shred any hardcopies. The approximate destroy date is April 2023.

Where and how will the signed consent forms be secured? The signed consent forms will be stored on my personal computer with password protection. Any hardcopies of the signed consent forms will be stored in a locked safe at my place of residence.

FUTURE RESEARCH

Once names are removed from the data collected for this study, the information could be used for future research studies or distributed to other investigators for future research studies without additional informed consent from you or your legally authorized representative.

STUDY CONTACTS

Any questions you have concerning the research study or your participation in the study, before or after your consent, will be answered by Merri Pedersen, [redacted], [redacted].

If you have 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 College of Doctoral Studies at IRB@gcu.edu; (602) 639-7804

VOLUNTARY CONSENT

PARTICIPANT'S RIGHTS

- You have been given an opportunity to read the informed consent;
- You have been given enough time to consider whether or not you want to participate;
- You have read and understand the terms and conditions and agree to take part in this research study;
- You understand your participation is voluntary and that you may stop participation at any time without penalty.

Your consent means that you understand your rights listed above and agree to participate in this study

____ ____________________

Signature of Participant or Legally Authorized Representative Date

Appendix D.

Copy of Instruments and Permissions Letters to Use the Instruments

Dear Merri Pendersen,

Thank you for your request. I am happy to report that you can consider this email as *gratis* permission to use the "Skills Inventory Survey" found on pages 67 – 68 of *Leadership: Theory and Practice***,** 7th Edition by Peter Northouse in your upcoming thesis or dissertation research as is required to complete your degree at Grand Canyon University. **Please note that this permission does not cover any 3rd party material that may or may not be found within the work. Distribution of the questionnaire is limited to 30 copies and must be controlled, meaning only to the participants engaged in the research or enrolled in the educational activity. All copies of the material should be collected and destroyed once all data collection and research on this project is complete. You must properly credit the original source, SAGE Publications, Inc. and provide a full citation.**

In addition, please accept this email as permission to include the Skills Inventory Survey in the Appendix of your dissertation. **Permission is granted for the life of the edition on a non-exclusive basis, in the English language, throughout the world in all formats provided full citation is made to the original SAGE publication. Permission does not include any third-party material found within the work. Please contact us for any further usage of the material.**

Any other type of reproduction or distribution of questionnaire content is not authorized without written permission from the publisher

Please contact us for any further usage of the material and good luck on your thesis/dissertation!

Kind regards,
Mary Ann Price
Rights Coordinator
SAGE Publishing
2600 Virginia Ave NW, Suite 600
Washington, DC 20037
USA

T: 202-729-1403
www.sagepublishing.com

Los Angeles | London | New Delhi
Singapore | Washington DC | Melbourne

Appendix E.

Skills Inventory Survey (Each item aligned with RQ 1, 2, or 3)

Instructions: Read each item carefully and decide whether the item describes you as a person. Indicate your response to each item by circling one of the five numbers to the right of each item.

Key:
1 = Not true 2 = Seldom true 3 = Occasionally true 4 = Somewhat true 5 = Very true

1. I enjoy getting into the details of how things work.	1 2 3 4 5
2. As a rule, adapting ideas to people's needs is relatively easy for me.	1 2 3 4 5
3. I enjoy working with abstract ideas.	1 2 3 4 5
4. Technical things fascinate me.	1 2 3 4 5
5. Being able to understand others is the most important part of my work.	1 2 3 4 5
6. Seeing the "big picture" comes easy for me.	1 2 3 4 5
7. One of my skills is being good at making things work.	1 2 3 4 5
8. My main concern is to have a supportive communication climate.	1 2 3 4 5
9. I am intrigued by complex organizational problems.	1 2 3 4 5
10. Following directions and filling out forms comes easily for me.	1 2 3 4 5
11. Understanding the social fabric of the organization is important to me.	1 2 3 4 5
12. I would enjoy working out strategies for my organization's growth.	1 2 3 4 5
13. I am good at completing the things I've been assigned to do.	1 2 3 4 5
14. Getting all parties to work together is a challenge I enjoy.	1 2 3 4 5
15. Creating a mission statement is rewarding work.	1 2 3 4 5
16. I understand how to do the basic things required of me.	1 2 3 4 5
17. I am concerned with how my decisions affect the lives of others.	1 2 3 4 5
18. Thinking about organizational values and philosophy appeals to me.	1 2 3 4 5

Scoring

The skills inventory is designed to measure three broad types of leadership skills: technical, human, and conceptual. Score the questionnaire by doing the following. First, sum the responses on items 1, 4, 7, 10, 13, and 16. This is your *technical skill* score. Second, sum the responses on items 2, 5, 8, 11, 14, and 17. This is your *human skill* score. Third, sum the responses on items 3, 6, 9, 12, 15, and 18. This is your *conceptual skill* score.

Total scores: Technical skill ____ Human skill ____ Conceptual skill ____

Scoring Interpretation

The scores you received on the skills inventory provide information about your leadership skills in three areas. By comparing the differences between your scores, you can determine where you have leadership strengths and where you have leadership weaknesses. Your scores also point toward the level of management for which you might be most suited.

Northouse, P. G. (2018). *Leadership: Theory and practice*: Sage publications.

Appendix F.

Interview Protocol

Thank you for agreeing to participate in this interview. The purpose of the interview is to gain an understanding of the skills that you utilize as an engineering leader. The information gathered from the interview may help determine the skills that need to be developed for future engineering leaders. Please let me know if there are any questions you do not feel comfortable answering. You may end the interview at any time if you deem necessary. The interview will take a minimum of 30 minutes. I would like to record the interview so I can review the data during the analysis stage of my study. Do you give consent for the interview to be recorded? Do you have any questions before we start?

General Questions

- What is your name?
- How long have you worked in the information technology industry?
- How long have you worked as a leader in engineering?
- What is your job title? How long have you been in your current role?

Interview Questions

Technical Skills: The first set of questions will focus on technical skills within the engineering discipline. Technical skills are specialized knowledge within a specific discipline (Katz, 1955). Within the information technology, technical skills may consist of designing and developing computer applications.

1. Once you moved into a leadership position, how did you utilize your previous technical knowledge? What technical skills do you utilize on a daily basis? What new technical skills have you acquired since starting in your leadership position?

2. As a leader, how involved are you with solving technical problems in relation to technology? Can you give me an example of when you have had to solve technical problems with your team?

3. How often do you get involved in technical decisions within your organization? Can you give me some examples of when you get into the details?

Human Skills: The next set of questions involve your utilization of human skills. Katz (1955) defined human skills as the ability to work with others.

4. What interpersonal behaviors do you associate with engineering leadership? Of these behaviors, which ones do you use in your leadership?

5. How do you feel about the way you relate to others within the organization, such as subordinates, peers, stakeholders, and upper management? Potential follow-up question: How have your feelings about relationships with subordinates changed as your leadership experience has increased?

6. How important is self-regulation in your leadership position? Potential follow-up question: What is an example of a time when you had to practice self-regulation in your leadership position?

Conceptual Skills: The following questions will focus on the utilization of conceptual skills in your leadership position. Katz (1955) identified conceptual skills as the ability to see the organization from a holistic perspective such as innovation, problem-solving and making connections with other groups in the organization.

7. How do you take manage innovation within your organization? Can you give some examples of how you encourage innovation?

8. What type of critical thinking skills do you utilize in your leadership position?

9. How do you handle complex situations that involve multiple teams?

Overall Skills:

10. Out of all the skills you utilize in your leadership position, which ones do you use the most and which ones do you use the least?

11. If you were to provide guidance to an upcoming engineering leader, what skills would you suggest they focus on improving?

Thank you for participating in the interview questions. I will provide a copy of your responses for review before publishing the results of the study.

Appendix G.

Demographic Information Questionnaire

Participant Pre-Interview Demographic Information

1. What is your current title?

( ) Manager

( ) Senior Manager

( ) Director

( ) Senior Director

( ) Executive Director

( ) Vice President

( ) Other ____

2. Do you currently reside in the United States?

   Yes ____ No ____

3. Do you currently have a LinkedIn account?

   Yes ____ No ____

4. How long have you been in a leadership role within the engineering industry?

( ) 0-2 years	( ) 9-11 years
( ) 3-5 years	( ) 12-14 years
( ) 6-8 years	( ) 15+ years

5. How long have you held your current title?

( ) 0-2 years	( ) 9-11 years
( ) 3-5 years	( ) 12-14 years
( ) 6-8 years	( ) 15+ years

Appendix H.

Research Questions and Data Source Alignment

Table 18. *Research Questions and Data Source Alignment*

Example:	**RQs**	**Northouse Skills Inventory Survey (2018)**	**Interview Questions**
#	**Research Questions** (List all below.)	**Northouse Skills Inventory Survey (2018)**	**In-Depth Interviews**
1	How do engineering leaders describe the utilization of technical skills in their leadership positions?	#1 I enjoy getting into the details of how things work. #4 Technical things fascinate me. #7 One of my skills is being good at making things work. #10 Following directions and filling out forms comes easily to me. #13 I am good at completing the things I've been assigned to do. #16 I understand how to do the basic things required of me.	1. Once you moved into a leadership position, how did you utilize your previous technical knowledge? What technical skills do you utilize on a daily basis? What new technical skills have you acquired since starting in your leadership position? 2. As a leader, how involved are you with solving technical problems in relation to technology? Can you give me an example of when you have had to solve technical problems with your team? 3. How often do you get involved in technical decisions within your organization? Can you give me some examples of when you get into the details?

Example:	RQs	**Northouse Skills Inventory Survey (2018)**	**Interview Questions**
#	**Research Questions** (List all below.)	**Northouse Skills Inventory Survey (2018)**	**In-Depth Interviews**
2	How do engineering leaders describe the utilization of human skills in their leadership positions?	#2 As a rule, adapting ideas to people's needs is relatively easy for me. #5 Being able to understand others is the most important part of my work. #8 My main concern is to have a supportive communication climate. #11 Understanding the social fabric of the organization is important to me. #14 Getting all parties to work together is a challenge I enjoy. #17 I am concerned with how my decisions affect the lives of others.	4. What interpersonal behaviors do you associate with engineering leadership? Of these behaviors, which ones do you use in your leadership? 5. How do you feel about the way you relate to others within the organization, such as subordinates, peers, stakeholders, and upper management? 6. How important is self-regulation in your leadership position? Follow-up question: What is an example of a time when you had to practice self-regulation in your leadership position?
3	How do engineering leaders describe the utilization of conceptual skills in their leadership positions?	#3 I enjoy working with abstract ideas. #6 Seeing the "big picture" comes easy for me. #9 I am intrigued by complex organizational problems. #12 I would enjoy working out strategies for my organization's growth. #15 Creating a mission statement is rewarding work. #18 Thinking about organizational values and philosophy appeals to me.	7. How do you take manage innovation within your organization? Can you give some examples of how you encourage innovation? 8. What type of critical thinking skills do you utilize in your leadership position? 9. How do you handle complex situations that involve multiple teams?

Example:	RQs	Northouse Skills Inventory Survey (2018)	Interview Questions
#	**Research Questions** (List all below.)	**Northouse Skills Inventory Survey (2018)**	**In-Depth Interviews**
Notes:	In-depth interview questions #10 and #11 encompass all three research questions holistically.		10. Out of all the skills you utilize in your leadership position, which ones do you use the most and which ones do you use the least? 11. If you were to provide guidance to an upcoming engineering leader, what skills would you suggest they focus on improving?

Appendix I.

Field Test Notes

A field test of the interview questions was conducted to ensure accuracy and relevancy to the topic of engineering leadership skills. Out of the four experts who provided feedback on the interview questions, three had terminal degrees and one had expertise in leadership and engineering. A feedback form and a list of the interview questions was provided to each expert via email. The form explained the purpose of the field test and included an activity checklist to help the experts analyze and provide feedback on the interview questions. The researcher reviewed the feedback from the experts and updated the interview questions. A summary of each expert's feedback is provided below as field test expert 1, field test expert 2, field test expert 3, and field test expert 4 to maintain privacy.

Field test expert 1, who has experience in engineering from a corporate and academic perspective, suggested clarifications on the meaning behind some of the terms used in the interview questions. Thus, the researcher provided additional clarification. The expert also noted how some of the questions were more complex with multiple dimensions, so the researcher made modifications to simplify the questions. Finally, the expert gave a suggestion for an additional question that the researcher had not considered. The additional question was added to the interview.

Field test expert 2 holds a terminal degree and is currently working in engineering. The expert provided feedback on some formatting errors and, similar to field test expert 1, suggested that some of the questions were complex and could be simplified. Additionally, the expert suggested one of the questions could be asked in a different way to get more information. The researcher took the advice of field test expert 2 and incorporated the suggested changes to the interview questions.

Field test expert 3 holds a terminal degree and is currently working in the academic field with a focus on leadership. Based on the expert's experiences with research, suggestions were made to ask for more general information at the beginning of the interview process. The expert provided ideas on how to obtain more information within each question to ensure enough data is gathered during the interview. The researcher has incorporated the suggested modifications to the interview questions.

Field test expert 4 holds a terminal degree and is currently working in the academic field with a focus on human resources and leadership. The expert provided suggestions of some additional questions to add to the interview. Similar to the feedback from the other field testers, the expert suggested simplifying the interview questions. The researcher incorporated the suggestions for additional interview questions.

Overall, the feedback from each expert was positive and they all had some similar suggestions, yet each person provided valuable comments that may help provide better clarity regarding the interview questions. The interview questions (see Appendix F) were revised, based on the feedback from the four expert field testers.

Appendix J.

Participant Recruitment

Grand Canyon University
College of Doctoral Studies
3300 W. Camelback Road
Phoenix, AZ 85017
Phone: 602-639-7804
Email: irb@gcu.edu

December 28, 2019

Would you like to make a difference in leadership excellence and provide insight for FUTURE engineering leaders? As a doctoral candidate at Grand Canyon University (GCU), I am leading a research study to explore how engineering leaders describe the utilization of technical skills, human skills, and conceptual skills in their engineering leadership positions. I am excited to seek your expertise and insight for this research effort sponsored by GCU.

I am recruiting individuals that meet this selection criteria:

- You are currently in a middle or upper level engineering leadership position.
- You have a LinkedIn account.
- You have more than two years of leadership experience in the information technology field.
- You reside in the United States.

You cannot be in this study if:

- You are not in a middle or upper level engineering leadership position.
- You do not have a LinkedIn account.
- You have less than two years of leadership experience in the information technology field.
- You reside in another country outside the United States.

The activities for this research project will include:

- Northouse Skills Inventory Survey (2018) ~ 10 minutes, online from your computer
- 1:1 Interview ~ 60 minutes via video conference
- Follow-up meeting for member checking ~ 30 minutes via video conference

Your participation in this study is voluntary. You will receive a $25 Amazon gift card if you complete the Northouse Skills Inventory Survey (2018), interview, and follow-up meeting. The gift cards will be distributed via email after the Northouse Skills Inventory Survey (2018), interviews, and follow-up meetings are completed.

All data in this study will be protected on my personal computer with password protection. The data files will be stored in a locked safe for three years. After the three years, if the data is deemed no longer needed, I will destroy the data.

If you are interested in participating in this study please start by following this link: https://www.surveymonkey.com/r/7DLLNKR. You may also contact me via email at [redacted] or phone [redacted].

Thank you!

Appendix K.

Summary Survey Data

Table 19.

Summary Survey Data

STATIC Survey Data by Research Subject - Engineering Leader

Research Subjects		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
STATIC Items	Related Research Question																							
1. I enjoy getting into the details of how things work.	R1 Technical	5	5	5	5	4	5	4	4	5	5	4	5	4	5	4	5	2	4	4	5	5	5	5
2. As a rule, adapting ideas to people's needs is relatively easy for me.	R2 Human	4	5	4	3	5	5	5	5	4	4	4	5	4	4	4	5	4	4	4	4	5	4	4
3. I enjoy working with abstract ideas.	R3 Conceptual	3	4	5	5	3	5	5	4	4	4	4	4	4	3	5	4	3	4	3	4	5	4	5
4. Technical things fascinate me.	R1 Technical	5	5	5	5	4	5	4	5	5	5	5	4	3	4	5	5	4	5	4	5	5	5	4
5. Being able to understand others is the most important part of my work.	R2 Human	4	5	5	5	5	5	5	5	5	5	4	5	4	5	3	4	5	5	5	5	4	5	5
6. Seeing the "big picture" comes easy for me.	R3 Conceptual	4	5	4	5	4	5	5	5	4	5	5	4	5	4	4	5	5	4	5	4	5	4	5
7. One of my skills is being good at making things work.	R1 Technical	5	5	5	4	4	5	5	4	5	5	5	5	4	4	3	5	4	4	5	5	5	4	4
8. My main concern is to have a supportive communication climate.	R2 Human	4	3	4	5	4	4	5	5	5	4	5	5	3	5	3	4	5	5	4	5	4	5	5
9. I am intrigued by complex organizational problems.	R3 Conceptual	5	5	3	3	5	4	4	3	3	4	5	4	3	4	2	4	3	3	5	4	4	4	5
10. Following directions and filling out forms comes easily for me.	R1 Technical	4	5	3	2	5	4	2	1	3	4	3	5	3	5	3	5	1	5	5	4	1	4	4
11. Understanding the social fabric of the organization is important to me.	R2 Human	4	3	5	4	4	4	4	5	5	5	5	4	4	5	2	5	5	4	5	5	5	4	4
12. I would enjoy working out strategies for my organization's growth.	R3 Conceptual	5	5	4	4	5	5	5	5	3	4	5	5	3	5	4	5	4	5	5	5	5	3	5
13. I am good at completing the things I've been assigned to do.	R1 Technical	5	5	5	5	4	4	5	2	5	5	5	5	5	5	4	5	4	4	5	5	4	4	5
14. Getting all parties to work together is a challenge I enjoy.	R2 Human	5	4	4	3	5	5	5	4	5	5	5	4	5	5	2	4	4	5	5	5	4	4	5
15. Creating a mission statement is rewarding work.	R3 Conceptual	3	4	2	5	4	3	2	5	3	4	3	5	3	4	1	4	4	3	4	4	5	5	4
16. I understand how to do the basic things required of me.	R1 Technical	5	5	5	5	5	5	4	3	5	5	5	5	5	5	4	5	4	5	5	5	5	5	5
17. I am concerned with how my decisions affect the lives of others.	R2 Human	4	5	5	5	4	4	5	5	5	4	5	5	3	5	5	5	5	5	5	5	5	5	5
18. Thinking about organizational values and philosophy appeals to me.	R3 Conceptual	3	5	2	2	5	4	5	5	3	5	5	5	3	5	1	4	5	4	5	5	5	4	4

Key:

1 = Not true 2 = Seldom true 3 = Occasionally true 4 = Somewhat true 5 = Very true

Appendix L.

Aggregate Data – Northouse Skills Inventory Survey (2018)

Table 20.

Aggregate Data – Northouse Skills Inventory Survey (2018)

Aggregate STATIC Data, N=23								
STATIC Items	Research Questions	1	2	3	4	5	Mean	SD
1. I enjoy getting into the details of how things work.	R1 Technical	-	1 (4.35%)	-	8 (34.78%)	14 (60.87%)	4.52	0.71
2. As a rule, adapting ideas to people's needs is relatively easy for me.	R2 Human	-	-	1 (4.35%)	14 (60.87%)	8 (34.78%)	4.3	0.55
3. I enjoy working with abstract ideas.	R3 Conceptual	-	-	5 (21.74%)	11 (47.83%)	7 (30.43%)	4.09	0.72
4. Technical things fascinate me.	R1 Technical	-	-	1 (4.35%)	7 (30.43%)	15 (65.22%)	4.61	0.57
5. Being able to understand others is the most important part of my work.	R2 Human	-	-	1 (4.35%)	5 (21.74%)	17 (73.91%)	4.7	0.55
6. Seeing the "big picture" comes easy for me.	R3 Conceptual	-	-	-	10 (43.48%)	13 (56.52%)	4.57	0.5
7. One of my skills is being good at making things work.	R1 Technical	-	-	1 (4.37%)	9 (39.13%)	13 (56.52%)	4.52	0.58
8. My main concern is to have a supportive communication climate.	R2 Human	-	-	3 (13.04%)	8 (34.78%)	12 (52.17%)	4.39	0.71
9. I am intrigued by complex organizational problems.	R3 Conceptual	-	1 (4.37%)	7 (30.43%)	9 (39.13%)	6 (26.09%)	3.87	0.85
10. Following directions and filling out forms comes easily for me.	R1 Technical	3 (13.04%)	2 (8.70%)	5 (21.74%)	6 (26.09%)	7 (30.43%)	3.52	1.35
11. Understanding the social fabric of the organization is important to me.	R2 Human	-	1 (4.35%)	1 (4.35%)	10 (43.48%)	11 (47.83%)	4.35	0.76
12. I would enjoy working out strategies for my organization's growth.	R3 Conceptual	-	-	3 (13.04%)	5 (21.74%)	15 (65.22%)	4.52	0.71
13. I am good at completing the things I've been assigned to do.	R1 Technical	-	1 (4.35%)	-	7 (30.43%)	15 (65.22%)	4.57	0.71
14. Getting all parties to work together is a challenge I enjoy.	R2 Human	-	1 (4.35%)	1 (4.35%)	8 (34.78%)	13 (56.52%)	4.43	0.77
15. Creating a mission statement is rewarding work.	R3 Conceptual	1 (4.35%)	2 (8.70%)	6 (26.09%)	9 (39.13%)	5 (21.74%)	3.65	1.05
16. I understand how to do the basic things required of me.	R1 Technical	-	-	1 (4.35%)	3 (13.04%)	19 (82.61%)	4.78	0.51
17. I am concerned with how my decisions affect the lives of others.	R2 Human	-	-	1 (4.35%)	4 (17.39%)	18 (78.26%)	4.74	0.53
18. Thinking about organizational values and philosophy appeals to me.	R3 Conceptual	1 (4.35%)	2 (8.70%)	3 (13.04%)	5 (21.74%)	12 (52.17%)	4.09	1.18
Key:								
1 = Not true 2 = Seldom true 3 = Occasionally true 4 = Somewhat true 5 = Very true								

Appendix M.

Composite Scores – Northouse Skills Inventory Survey (2018)

Table 21.

Composite Scores – Northouse Skills Inventory Survey (2018)

Participant	Curent Title	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Scores		
		T1	H1	C1	T2	H2	C2	T3	H3	C3	T4	H4	C4	T5	H5	C5	T6	H6	C6	**Technical Skills**	**Human Skills**	**Conceptual Skills**
Participant 1	Director	4	4	4	5	5	4	4	5	3	5	4	5	4	5	3	5	5	4	**27**	**28**	**23**
Participant 2	Manager	4	4	4	3	4	5	4	3	3	3	4	3	5	5	3	5	3	3	**24**	**23**	**21**
Participant 3	Senior Director	5	4	3	4	5	4	4	5	4	5	5	5	5	5	4	5	5	5	**28**	**29**	**25**
Participant 4	Senior Manager	5	4	4	5	5	4	4	5	4	4	4	3	4	4	5	5	5	4	**27**	**27**	**24**
Participant 5	Vice President	5	5	5	5	4	5	5	4	4	1	5	5	4	4	5	5	5	5	**25**	**27**	**29**
Participant 6	Senior Manager	5	4	5	4	5	5	4	5	5	4	4	5	5	5	4	5	5	4	**27**	**28**	**28**
Participant 7	Director	4	4	3	4	5	5	5	4	5	5	5	5	5	5	4	5	5	5	**28**	**28**	**27**
Participant 8	Director	4	4	5	5	3	4	3	3	2	3	2	4	4	2	1	4	5	1	**23**	**19**	**17**
Participant 9	Director	5	5	4	4	5	4	5	5	4	5	4	5	5	4	5	5	5	5	**29**	**28**	**27**
Participant 10	Director	2	4	3	4	5	5	4	5	3	1	5	4	4	4	4	4	5	5	**19**	**28**	**24**
Participant 11	Director	5	4	4	5	5	4	5	5	4	4	5	5	5	5	4	5	5	5	**29**	**29**	**26**
Participant 12	Senior Director	5	4	4	5	5	5	5	4	4	4	5	4	5	5	4	5	4	5	**29**	**27**	**26**
Participant 13	Senior Director	4	4	4	5	4	5	5	5	5	3	5	5	5	5	3	5	5	5	**27**	**28**	**27**
Participant 14	Senior Manager	5	4	4	5	5	4	5	5	3	3	5	3	5	5	3	5	5	3	**28**	**29**	**20**
Participant 15	Vice President	5	5	4	5	4	5	5	4	4	5	5	5	5	4	4	5	5	4	**30**	**27**	**26**
Participant 16	CTO	4	5	4	5	5	5	4	5	3	1	5	5	2	4	5	3	5	5	**19**	**29**	**27**
Participant 17	Senior Manager	4	5	5	4	5	5	5	5	4	2	4	5	5	5	2	4	5	5	**24**	**29**	**26**
Participant 18	Senior Manager	5	5	5	5	5	5	5	4	4	4	4	5	4	5	3	5	4	4	**28**	**27**	**26**
Participant 19	Vice President	4	5	3	4	5	4	4	4	5	5	4	5	4	5	4	5	4	5	**26**	**27**	**26**
Participant 20	Vice President	5	3	5	5	5	5	4	5	3	2	4	4	5	3	5	5	5	2	**26**	**25**	**24**
Participant 21	Senior Director	5	4	5	5	5	4	5	4	3	3	5	4	5	4	2	5	5	2	**28**	**27**	**20**
Participant 22	Vice President	5	5	4	5	5	5	5	3	5	5	3	5	5	4	4	5	5	5	**30**	**25**	**28**
Participant 23	Vice President	5	4	3	5	4	4	5	4	5	4	4	5	5	5	3	5	4	3	**29**	**25**	**23**
	Mean/Average	4.5	4	4	5	5	5	5	4	4	3.5	4.3	4.5	4.6	4.4	3.7	4.8	4.7	4.1	26.52	26.91	24.78
Key: 1 = Not true 2 = Seldom true 3 = Occasionally true 4 = Somewhat true 5 = Very true																						

Appendix N.

Excerpts of Coding

Table 22.

List of Codes, Sample Quotes, Frequencies via MAXQDA (Frequencies are the number of times a word or phrase fit into the associated code in the interviews.)

R1: How do engineering leaders describe the utilization of technical skills in their leadership positions?		
Codes	Samples Quotes	Frequency
Mentoring-Coaching	P5: mentoring and helping the individuals within my team grow their skills and understand how things actually work P7: it's just really handing off more of the-the day-to-day and really trying to grow people in their roles. P9: The leaders that I coach and mentor, I leverage my engineering discipline of how you take a problem, decompose it, prioritize things to try to solve it. P12: use that information to help the new folks that come in, to guide them as to what is right, how to do the right things, while developing software. P13: Depending on the day, I would say the other thing is the estimation part, coaching and mentoring the team on software estimation, level of effort, schedule, things like that.	6
Keeping Up with Technology	P2: I try to stay abreast of technology, and just understand what's there. P3: I've educated and gotten more on my own as well as obviously just with working with the teams getting through spending time with them.	11

	P4: "Hey, guys, there are better ways to present the data." P5: I use the side projects as opportunities to learn new languages, new frameworks, new technologies. P7: I try to stay up on the trends. I try to stay up on the technology advancements but I'm certainly not an active practitioner of the technology.	
Identifying Best Practices	P10: Part of my critical skills is just always just verifying I guess and checking things out for myself. P12: As a leader when I started learning new skills, I used those in a similar way to teach my leaders on what are the best practices, what should we be doing as an organization.	3
Technical Understanding	P2: draw on my technical experience to help solve problems P3: I do think having good technical skills to be able to be educated enough to have an opinion based on facts. But I do think you don't have to be the smartest person in the room. P5: using your base technical skills and understanding of how things work P12: There are times when you can help them understand a solution a little bit better based on your experience and past experience working on similar problems and explain it in technical terms to them. P1: I don’t need to know the nitty-gritty details, but walk me through how these systems work or how they work so that I can understand conceptually and have that context P10: I'm just giving them- here's how we'll do it. This is what you should be doing from a	40

	technical aspect, the high level. That's what I use probably on a daily basis. P5: Then as more of an executive leader, you're taking your experience and your technical skillset and judging. P14: We're constantly designing feature enhancements and improvements. P9: You have to understand, you may not know all the nitty-gritty, but there's basic principles of engineering that always apply P13: I would say I don't code, and I really try and stay out of it, but what it is, is more of the context and the software practices and software design practices, the composition. P6: That's where being able to understand how things work, how the pieces fit together, how if I was to have done this 15 years ago, how would I have done it because what doesn't change over time is really the logic paths P4: So if there are any reports out there, half of the time I feel like I'm spending more time trying to understand the report and there are times if there is no report there then you'll figure out to write a query here and there and you might end up learning something technical along the way.	
Technical Base to Build Relationships	P2: One of the reasons I'm able to deliver a lot of times than most of the time, on time and on budget is because I built those relationships with other people and work with them. P5: using your technical language to build a relationship with that person P7: I think it [technical base] was the piece that gave me competence to be able to have those types of conversations where people could relate to me now that I actually knew what was going on, as well as being able to help them through challenges too	21

	P9: It [technical base] helps me with interacting and leading engineers P10: my technical skills would be the engine to navigate to how they did things. You're always using that, I guess you could say, to help figure out where you're at, it's your compass.	
Dependency on Technical Team	P1: my focus has always been, “I need to understand how things work.”, so I have my subject matter experts on my team or on other teams walk me through. P3: I'm probably less involved than many [in technical details]. P6: Start soliciting answers from rest of the team and developing the relationship with them and help them when they need it. Pull back and generate, ask for their opinions but really build those relationships and partnerships and keep discussing	6
Transitioning Away from Technical Details	P1: I don't think my technical skills are needed to be super in-depth, such that I can go in and solve this from -- go in and code the solution. I don't think it needs to be there. P2: Make sure that you're not overlapping and doing things that they should be doing, but you're finding ways as a leader to support them. I guess leadership focuses on what leadership's skills and responsibilities are. P7: I would tell you my technical expertise have definitely dwindled in terms of understanding what to do hands-on and being able to do things real-time. P8: There has been some use for it though obviously not as heavy as when I was hands on P11: As you go higher up in the org, and you are managing managers and not individual	24

	contributors, those technical skills are still useful but not to the same extent as before. P14: I want to understand what they're proposing and generally let them do their job and only interject myself when I really think we may be going down a wrong path or if I have concerns about a particular approach.	
Less Use of Technical Skills	P4: technology skills were actually coming in my way to manage people P7: I believe that the big challenge with a lot of executives that are in a similar role, you know, because a lot of technical people stay technical and move into leadership problems. They're very good and probably better than I could ever be in terms of technical implementation, but they lose the other side, the human element. They lose the forward-thinking, they forget how to enable the workforce.	9
Delegating	P1: I'm a firm believer that you want the smart people below you empowered and doing what they need to do, and not feel like, oh, I have this crutch that, in case I run into a problem, they'll solve it for me. I want to pull the solution out of them, versus me be the one provide it. P2: I would say if it's an up and coming engineering leader that they probably are strong technically, and that's most likely how they've moved up the ladder, so to speak into a leadership position. A lot of it that they should focus on initially is really understanding what their new roles and responsibilities will be. Where they need to begin delegating because that's the hardest part when you move into a leadership role. It's a complete transition from what you did before as an individual contributor.	2
Guiding-Coordinating	P1: I also value (since engineers typically can get into that analysis paralysis mode) the	20

	driving people or pushing people to, “Hey, what's that next step we need to take? Let's take that step,” versus, “Let's sit here and think about it and talk about it day after day after day.” , so that skill I think is very important. P13: I would say it's less about solving. I'm not really involved in solving individual technical problems, it's more or less. If I do get involved with a technical problem, it's to guide and coordinate, "Hey, this thing feels like this. We need to get people together across org or across team." It's more about facilitating the right conversations and the right teamwork. It's not really about debugging anymore or re-engineering things.	
Technical Decisions	P2: I think I do that [technical decisions] pretty frequently but there may be direction on strategy to-- At least gives me a little bit of latitude on how to implement that with the team but just pretty frequently. P6: I have multiple teams, and each team has multiple products. As we go to build one product, and then we have a design question. We start out with the design discussion, and as the team does the design work, that's where I'm going to step in and ask a couple of questions, and go back to, "Well, how do we handle this scenario? What happens if you triple the load on something?" You're just asking those kinds of questions, which usually, again, prompts either more answers, which, even if it's, "Oh, that's not a problem. P7: I would say that the majority of the time I would leave it to the teams to figure out technical problems. P8: I actually make most the technical decisions for the company, but it's not done in a vacuum. I report to the CEO and he has the	9

	final say so on direction in spending but when it comes to the nitty-gritties, that's up to me. P12: When a new project comes in and it is handed over, during that time, I am very much involved in deciding along with the team what technologies to use and what is the best way to go.	

R2: How do engineering leaders describe the utilization of human skills in their leadership positions?		
Codes	Samples Quotes	Frequency
Knowing Yourself	P5: I have to slow myself down and I have to look for comprehension across the room and see if the people that are there are following. Some people, that comes very naturally to. That is not for me. P9: I think you also need to know who you are	2
Empathy	P5: it really comes down to self-awareness is the first thing to happen before you can self-regulate. Self-awareness can only happen if you have empathy.	1
Aware when Wrong	P5: And if they are not, ask yourself, "Okay, well, clearly, what I just said didn't resonate with this person. Why? What's their perspective? How do I need to frame this message? Or maybe I'm wrong, and they're defensive, because they know I'm wrong. And I need to take that hint. And I need to figure out why I'm wrong.	2
True to Yourself	P9: I make sure that's really what I am because you have to be true to yourself.	2
Listening	P11: You wanna be yourself, but you also wanna make sure that you think before you act and you think before you talk - at least	1

	that's my idea or that's what I believe in. I don't want to jump to conclusions or lockout an opinion without having thought about all possible scenarios - that's how I normally interact with people. I try to listen and understand their point of view before I venture an opinion. I think it's really important because once you've made certain comments and you set a perception, it's very difficult to change those perceptions.	
Staying in the Moment	P9: I self-regulate to the point that I try to stay in the moment.	1
Controlling Frustrations	P11: I used to be impatient and I used to be impulsive in the past. But over the years I've become a lot more controlled and I don't speak out tone or I don't try to interject in conversations unless I feel like I have something to contribute that's valuable. P12: I try to control myself internally to not get angry or frustrated at least before the people, when I'm working with them. P14: Let me get myself into control and in the right mental framework, or mindset, I should say, to listen to my team, hear what the individual's saying, make sure, again, that I fully understand what they're saying and then we can talk about, what should we do, or whether it's a technical problem, or if it's a situation that maybe I think does happen from time to time that maybe they didn't conduct themselves in what would be an appropriate business fashion.	4
Over Self-Regulating	P5: Now the danger of self-regulation is there's certainly too much, because, there is a skill in knowing, there are times and places when it's appropriate to drop an F-bomb in the middle of a meeting. Some people might not do that because they're regulating too much and as a result, they lose their impact.	3

	Likewise, if you regulate so much and you want to make sure that everybody is included and nobody is included and you spend all of your time grooming (socially grooming) everybody, you actually won't accomplish anything. P6: there's a time to not be self-regulated, and there's a time to be self-regulated P13: I think it's important, in that, you don't kill someone's motivation or adversely impacting someone's motivation. I do think, situationally, a little bit of outburst is probably good, though, but when I do that, I follow it up really quickly with an explanation of, "Okay, it's the situation, it's not you. Here's what you do well." I come back with a positive reinforcement.	
Controlling What Sharing	P3: I'm controlling more of what I'm sharing and controlling my thoughts	1
Self-control	P3: I wasn't as good at self-regulating when I was sharing with the teams I got fairly emotional and I felt unfortunate about it, that I couldn't have control that more P4: self-regulation is super important P5: I think and I talk really fast and if I am not making space in the room for other people to think and to talk, I end up being the only one that's thinking and talking P8: self-regulation is really important. For me in particular, one of the thing that was harder for me to overcome	7
Calm, Cool, & Collected	P1: I pride myself in being calm, cool and collected, not being too high or too low for any given situation, because the people you're working with and the people that work for you feed off that, positively or negatively. P2: I don't get frazzled under stressful situations. I think I remain calm and I've	10

	actually received that feedback from some of my direct reports. P4: My thing in general, even if I get upset, I do not scream at people because that's not my personality. That's not my thing P7: I think you've got to have some sort of an even keel mentality P9: I think is just my calmness to approach problems. People can get crazy and priorities and this and that and, and things can go nuts. But it's staying just calm and say, "Okay, great. We have an issue. What are we gonna do? What's the right approach, what do we need?" And using some of those basic tenants of, of engineering discipline, but calmly using them and getting a plan together.	
Self-Reflection	P9: I am a person who does a lot of self-retrospectives. P10: Some of the stuff is reflection on myself, it was what didn't I communicate or what did I do wrong? What could I have done better? At that point, I just stopped and then I had to start asking those questions like, "You were really interested in this. Now what happened? Tell me what gave you that interest? Why did you change your mind?" I think that's very important to do that.	3
Empathy for others	P5: I can't understand how my behavior is affecting you unless I can put myself in your shoes, read your reactions, read your facial expressions and understand how you're reacting to something that I'm doing. P6: Whether it's empathy for your engineers, or it's empathy for your customers, or it's empathy for your peers. That's probably the biggest one. The statement's always made that people are the most important, most valuable resource that we have.	9

	P9: I try to look at things from their position. I use pretty much that to help me determine the best approach to work with people. P11: I would say it's empathy- your ability to listen to your people, understand what they're dealing with, and how you can help them to be successful in their roles.	
Persuasion	P7: Another skill that I think interpersonal that's really important is having persuasion skills, at least giving people an understanding of what your thoughts are and what your feelings are on how to proceed with things. It's really that to me is super important,	1
Navigating Politics	P1: kinda balancing that act of creating a tool that we're not stepping on people's toes and we're getting them to want this, and so it's really more strategic thinking and positioning it in such a way that it's a win-win P8: And then the interpersonal relationships and, unfortunately, politics in the office always come into play. And so you think about that and, you know, how you can work with everybody to achieve the goal.	4
Understanding People	P4: in a leadership role, it's very important for you to study people. As an engineer, you probably never paid attention to body languages. But as an engineering leader, you better start watching out on body, like looking at people and reading them and understanding what they think and see. So, in fact, people end up studying computer science, right? And they're really good at programming, that what I was when I did my bachelor's and my master's. But then, once you come out, maybe there are some folks that understand it quickly and say like, "Oh, okay," I need to really focus on the psychology part a little bit. The sooner you realize, the better off you are. P5: "I often wished that when I've got my undergrad, I would've gotten it in Sociology	7

	or in Organizational Dynamics”. And the reason that I say that is, the technology has always come easy to me. And I think more often than not, people that go in engineering programs, go into them because they tend to be relatively lucrative careers and there are things that you're naturally good at. You kind of fall into those things and it's a very logical and reasonable choice and that why I did it, but - realistically, I probably would have been able to learn the technology just as easily without a degree in that, in a computer science space. P6: People skills, in general are probably the most used and whether it's my team or its peers, or its customers or its the executive team or whatever it is. That's pretty much understanding people. P9: having a genuine interest in people	
Understanding the Room	P5: The actual skill that leads you to be an influential person are the skills of being able to read a room, being able to understand the tone, and temperature of the room, being able to separate problems because usually, you walk into a room, you walk into a meeting, and everyone has five problems that all get conflated together to be the same thing. P7: you have to understand your audience - what they're doing and how to engage with them and what's the right level of engaging.	2
Understanding Personalities	P3: I think being able to kind of read and interpret different personality styles. I think that it's important, especially, I think especially engineers, can be more likely to be kind of inner focused, not collaborative, but, a little bit, "Just tell me what I need to do," and "I'm gonna do my job," and that sort of thing and so I feel like getting the understanding of the different personality styles and how to work with them, is a skill that I have and that I	5

	think that I'm pretty good at doing of getting information or getting motivation or getting what is needed through being able to adjust my style based on their personality style. P10: You having to deal with people's personalities. I think that's very important to understand, the way people work with how they think. Why is something so important to them that helped to resolve conflict and listen, and make it safe, again, being on a safe environment.	
Ability to Interact with Others	P7: Tailoring your content or context to the audience. Maybe you're talking to an executive, you wanna be brief and to the point. Whereas with somebody you're partnering with, you wanna make sure that you're deeper and understanding the commonalities of what you're working with. And then when you're working with people that might work for you, you wanna explain the why. Why are we doing X, Y, and Z and being a little bit more expressive in what you're doing and a lot of times is asking for help in that delivery, but that's how I see it, at least, in my day-to-day. P1: I think the number one skill that's needed for engineering leaders is the ability to collaborate with others, that's the thing I prioritize above all else, so whether that's me reaching out to my peers and or customers, the people we work closely with or my team works closely with to understand their needs and their view of the world so I can understand what it's like to be in their shoes. P2: I try to be I think collaborative as much as possible and find opportunities for us to share knowledge and work together because that's how I approached my team with my leadership.	89

	P3: I think, being able to see different points of view. I think being able to be collaborative yet directive when you need to. P5: And when you become a manager of managers, you realize very quickly you're not going to be effective until you can start partnering with other people because the thing that you need to fix probably isn't just internal. Almost always the things that you need to fix require coordination across multiple entities and so you start to build this skillset of partnering with that peer group. P11: Now I am seeking out those interactions and taking opportunities more often to build those relationships. And it's important to have those relationships, however good you are in delivering, sometimes it doesn't matter unless you are able to build trust and relationships with your stakeholders. I'm learning that and understanding the importance of that more and more as I grow in this role or get to the next level. P5: when you become more at the VP level, you are definitely expanding that bubble in three dimensions. You're partnering with your peer, you're partnering with your boss because you see things in some other organization that's completely outside yours that is a close dependency and you're going to try to work directly across that level but you realize the bosses probably need to be aligned as well, which means you need to be investing in the relationship with the other person's boss. P7: If you can get everybody on the same page because I think if you're not on the same page at the get-go, those complex problems, those large scale programs will fail. P7: I'm a huge believer in transparency and the human element of that is that I think people think that you're more sincere and	

	trustworthy in terms of what you're bringing to the table P8: So, for me, you know working with a team that is usually are very bright people and so to me, you have to be very transparent with them. P10: sometimes people, since it's very personal, solving a problem in their particular way that they spend a lot of time, gets very personal. Sometimes they will push back with emotion or frustration that you didn't understand them. And so, it's not uncommon in some places that people are yelling at each other because of that conflict. But conflict is a big part of software engineering. P11: And, also there is a 50/50 concept that you always need to understand that there are two sides to every situation, and you have to try and understand both viewpoints. If you are in a conflict, or you have a disagreement or you're trying to make a decision jointly with another group, always understand that you have your viewpoint and then you also need to understand where the other party is coming from. Those are two important skills. P13: I find that in engineering there's a lot of strong opinions. You can easily derail something into a religious or political debate without really intending to. I do use similar techniques of asking open-ended questions and trying to help people come to the conclusions I would like them to. Yes, I'd say they're fairly similar. There may be some subtleties, but for the most part, they're pretty similar.	
Communication Skills	P1: being able to communicate with them openly and frequently such that expectations are set, and they know what we're doing and	55

	why. And always being sure we are on the same page. P2: Communicate as much as I can about the things that I know I can share with them. P4: Need to be able to work with obviously the team, internal and external customers, and with senior leadership, right. So there are multiple flavors of people that you need to work with. The level of detail that you pass on to a developer is going to be very different compared to the leadership chain who really wants to hear the summary of the problem. And the business partner might be interested in like metrics. P5: If you can't effectively communicate that idea, and if you can't influence the right people, you're just going to be the really smart guy that everybody laughs at and ignores and goes about their day. P8: My communication skills have significantly improved over the years. When you're an engineer, hands-on, it's great if you have great communication, that makes you a rare engineer, but if you're going into management, you've got to have them. You've got to improve those skills. P10: Communication skills are probably high on my list in order to pull off almost anything P12: If suppose I'm bringing a manager under me, or I'm bringing a developer under me and asking him to-- Grooming him to be my leader. Then one of the big things that I expect, or I continue to teach them is good, strong communication skills. P13: Communication - I think it's a big challenge and we, especially, in technology we value all the technical checkmarks on someone's resume, but the thing that I've seen impact, adversely, more projects and more	

	features than not is communication, either the inability to articulate a solution or the inability to engage active listening to really understand what you're delivering and if you're solving, so I'd by far communication.	
Relationship Building	P2: A lot of it's networking to a certain degree, understanding who to contact for certain situations and just understanding when to reach out to them for looping them into things that we're working on just to give them a heads up. P3: I think the ability to get what is needed done based on my relationships. P4: It's all about building that rapport, making sure that they feel comfortable with the questions, not threatened. P12: As far as my superiors are concerned, I always work with them with high respect, and I look at what I need to deliver when they ask me to make sure that that is a priority for me.	19

R3: How do engineering leaders describe the utilization of conceptual skills in their leadership positions?		
Codes	Samples Quotes	Frequency
Identifying Key Players	P6: Ultimately identify key players with the skill sets from each of the team and provide them with-- Get them in a room and make sure that they all have the same objective of accomplishing and solving the problem and let them tackle it. P8: I really like whenever possible just getting all the people involved in the project in a room.	2
Negotiation	P2: A lot of what I do and what I tried to drive is those conversations around what they need and when they need it. That's a constant shift	2

	of priorities and work in flight, and it's also really a negotiation. P8: n order to get that process going, your stakeholders need to buy into it too which is some of the VPs we are working with that are in totally different areas, that are not in IT.	
Decision Making	P1: I have to force myself to drive to that and be more of a driver. I think that's very important otherwise, engineers are really good at just tinkering and having nothing to show for it. P5: if you don't have the ability to critically assemble that information, ask the right questions and make good judgment calls, you're never going to be effective in that role. P10: We have this term that we use - analysis paralysis. That I don't spend so much time in critical thinking in evaluation that I never make a decision. I think being able to refine that quick skill to be able to make the decision quick and move forward because my engineers don't have all day.	3
Asking Questions	P3: every critical thinking - it starts off with the questions - in my case, I would be asking some powerful questions so that they think out of the box. P5: Taking data from many different places, assembling it together and framing it in questions that helps people, like broaden their horizons and see things from a different level. P6: There a lot of the stating problem, understanding the situation, understanding constraints that we have, asking a bunch of questions around why, where and how. P14: Okay, so, a lot of times, people come to me with the solution, or at least, their solution. Come and say, oh, we have to do this, and I find it's often important for me to back up. Ask the powerful questions and just make sure that,	17

	first of all, that they fully understand the problem or issue, because it's not uncommon that sometimes people jump to their conclusions without maybe fully understanding the problem, or without really considering what are all of the options to solve that problem.	
Understanding the Why	P3: I think trying to not just look at what the ask is but trying to get a better understanding of the why and the value. P6: There a lot of the stating problem, understanding the situation, understanding constraints that we have, asking a bunch of questions around why, where and how.	2
Problem-solving	P2: I try to approach problems if I can early on by discovering an analysis of what that problem is really understanding the scope of it and trying to frame the problem. Because once you can frame it, then you can approach that problem with different solutions. P5: Taking data from many different places, assembling it together and framing it in questions that helps people, like broaden their horizons and see things from a different level. P6: You learn that as management it's our responsibility to solve this problem and making sure that we all are on the same page about solving the problem. P7: I think it's extremely important to figure out how to be able to break those down into tangible items that are workable. P12: One of the things that I pride myself is when there is a problem, a very complex problem, I feel that I can break it into simple ones, and I can then link it together to solve the problem. P13: I think there's problem-solving, tactical, full organizational systems debugging, and then there is project management, sort of that	16

	the, okay, in order to make this whole thing happen, we've got to get three teams together, and identify all the dependencies, cross dependencies, what's the sequence of development, what is the integration testing, we got to do? Things like that. I think there's really those two different realms that we deal with mostly. P14: Okay, so, a lot of times, people come to me with the solution, or at least, their solution. Come and say, oh, we have to do this, and I find it's often important for me to back up. Ask the powerful questions and just make sure that, first of all, that they fully understand the problem or issue, because it's not uncommon that sometimes people jump to their conclusions without maybe fully understanding the problem, or without really considering what are all of the options to solve that problem.	
Ability to Understand the Business	P5: First and foremost, is actually learned the business context in which you're in. How does the company make money? How does the company spend money? How much is desirable and how much is undesirable. The earlier that you can start putting your work into that business context, the sooner you're able to build the influence, the sooner you're able to motivate people. Being able to create the view of, "This is the world, and this is where we fit." P12: It's almost a business level that I have to sit with them and explain.	4
Architecture Direction	P9: Then the next level of critical thinking is going to be on our architectural direction. What people are talking about, where we want to go, people's ideas, ultimately is that the right direction where we want to go, that aligns with where the company's going. P11: obviously you use critical thinking in understanding how your architecture can be	5

	improved to be more resilient and we're always trying to improve efficiencies. P12: During that time, this is not a technical solution, they came to me with the problem on how to get work done. Then these are two different cultures and I had to explain them on how my methodology is, how we have to respect every individual's input, and how to solve it. Literally, I had to draw a picture and show them how I changed the model within my team.	
Big Picture	P3: Prior roles, I've been a little more limited in a team focus and smaller group focus and I've been kind of aware of the bigger picture, but I think now I'm trying to have that be a more important aspect of what I'm thinking about and thinking more broadly. P5: One of the biggest unsung elements of that is employee engagement. When my teams understand how they fit in and they understand the bigger picture, they make better choices at the small scale - because you and I both know. P11: It's always important to understand the big picture and how you fit into that big picture and how you can work within the organization to deliver what you have to deliver. P13: I think there's two things there's our stakeholders, like any people or like many people, they bring requests for new features to us based on the problem of the day. They very rarely think about how it fits in the grand scheme of things or along a thread of what the capability is that our software does, most of it is really getting them to confirm what is the true requirement here, let's talk about how you use that whole capability.	5

Forward Thinking	P7: I believe that the big challenge with a lot of executives that are in a similar role, you know, because a lot of technical people stay technical and move into leadership problems. They're very good and probably better than I could ever be in terms of technical implementation, but they lose the other side, the human element. They lose the forward-thinking, they forget how to enable the workforce. And you've got, to me you've got to be able to look at all of those in parallel, and try and think, you know, six months, nine months out there on how you bring all those things together. P7: I would tell you I use the those - what I'll say is like those conceptual skills the most. I spend a lot of time trying to figure out where we want to go, what we want to do, how do we bring all that together? How do I work that back through the organization? P8: In terms of hands-on skills, a lot of vendor management, contract negotiation, budgeting, things like that because you're, you know, like I have all of IT, so we're always looking ahead of, okay, here's where we are today, but what are we going to need in a few months or what unexpected thing may come up? And we've got to make sure we've got reserves in case. P11: I would say that as a leader you should set the vision for your team, but you have to be able to inspire your team to achieve that vision but you should be stubborn on the vision, but you should be flexible on the details, on how do you achieve that vision.	6
Grounding Innovation in Reality	P2: I'm constantly innovating with the team. I think we're doing a lot of things for the first time within the company in terms of the data engineering and moving that to the cloud. A lot	15

	of it is there is no blueprint for our business model. P4: you start realizing that it's not about just answering the immediate need of the business- but you have to think, with the future part in mind- what really makes sense for the portfolio and is there anything new that you see through which needs to be done from an innovation point of view. I really don't have a set example there. That's one area that I know I really lack. P9: So embrace innovation as long as it's grounded in some sense of reality and current technology. P10: And we show you that value and we hold them accountable by just not letting them off the hook of stuff. I'm trying to make innovation structured at first until we build that trust. P11: one of the things that we try, we are trying to do now is try to do technical or technology uplift or platform upgrades and especially NC and those kinds of opportunities to do innovative things within our team and within our platform. P13: It's very seldom free form, "Well, let's just innovate," I say in the current role, the innovation is more about looking at business processes, looking at where technology can help out, that's really the innovation that I'm dealing with now.	
Creating Fortuitous Interactions	P3: I think the kind of the more we're learning about what everyone else is trying to do, then, encouraging a partnership with someone else in a in a different functional area to say, we should try to figure out how we can help solve this. Let's get together and brainstorm and come up with some ideas and if we want to pull in other people and that kind of thing, but I think trying to identify based on the challenges and the different initiatives. What	3

	are some things that we could propose to help solve the business capabilities that they're trying to develop. P5: As a leader, you can absolutely control the rate of innovation based on how frequently you're creating an environment for those fortuitous interactions to happen.	

Table 23.

Sub-themes, Codes, and Analytic Memos

Sub-themes	Codes	Analytic Memos
Using a Technical Base	Mentoring-Coaching; Keeping up with technology; Identifying Best Practices; Technical Understanding; Technical Base to Build Relationships	Engineering leaders indicated that they use their background in technology and software engineering to mentor and coach their teams. While the leaders indicated they are not in the details of the technology anymore, they do think it is important to stay abreast of the latest technologies to help guide their teams. A portion of the engineering leaders felt it was important to help their teams understand best practices of software engineering. Technical understanding was one of the biggest sub-themes discussed under technical skills. Although the leaders were not in the details, they indicated that understanding software engineering was important for them to be successful as an engineering leader. They noted that they did not need to be the smartest person in the room, but technical skills helps leaders make solid decisions. Numerous codes were identified as technical understanding, such as the ability to manage software vendors, the ability to help with software designs, and applying engineering principles.

		Overall, all 14 engineering leaders were in general agreement that it was valuable for software engineering leaders to have a solid technical base with a good understanding of engineering principles to be effective when working with people inside and outside the organization.
Transitioning Away from Details	Dependency on Technical Team; Transition Away from Technical Details; Less Use of Technical Skills; Delegating	The software engineering leaders indicated that as they moved from individual contributor roles to leadership roles, they needed to move away from the technical details. Some of the leaders indicated that their technical expertise started getting in the way of their ability to lead the team. Other leaders felt their technical expertise was a pathway to help them become a better software engineering leader. When transitioning into a leadership role, the software engineering leaders noted the importance of enabling, developing and supporting their teams. Overall, the engineering leaders agreed that they use their technical skills less as they have transitioned into leadership roles. Delegating technical responsibilities and allowing the team to do the detailed technical work can allow the leader to focus on building other skills, such as human and conceptual skills.
Setting High Level Technical Direction	Guiding-Coordinating; Technical Decisions	Although the leaders agreed that it is good to step away from the day-to-day technical details, it is still important to understand the technology enough to help guide the overall approach and technical/architectural direction. The leader can help drive the vision and meet the objectives of the organization by ensuring the team is going in the right direction. Part of setting the high level technical direction is being a facilitator to help guide the team by asking questions and generating discussion.
Problem-solving Skills	Problem-solving; Cross Team Problem-solving;	Problem-solving as an engineering leader is multi-faceted. In the higher level leadership roles, software engineering leaders indicated

	Asking the Right Questions; Driving Technical Details	they get involved with problem-solving by looking at patterns across multiple teams. Lower level leaders discussed how they dive into the details with their teams when a problem needs to be solved. Regardless of the level of leadership, software engineering leaders agreed that one of their key skills was asking the right questions, which was also identified as a key skill when talking about conceptual skills used during critical thinking.
Self-Awareness	Knowing Yourself; Empathy; Aware When Wrong; True to Yourself	Self-awareness was mentioned as an important skill for engineering leaders - such as the ability to realize when you are not making a connection with someone and understand how your behavior is impacting others. Taking the time to be introspective and honest with yourself about your ability to connect and communicate with people. Some engineering leaders noted that this skill did not come naturally to them - they have to continuously work on it.
Self-Management	Listening; Stay in the Moment; Controlling Frustrations; Over Self Regulating; Controlling What Sharing; Self-control; Calm, Cool, Collected; Self-Reflection	Self-management - the ability to control emotions - was seen as very important by all the engineering leaders. One key term that surfaced from many of the engineering leaders was the ability to stay calm, cool, and collected during stressful situations. The impact of not staying calm in stressful situations was the risk of impacting relationships (tie to Relationship Management) - no one wants to work with someone who cannot temper themself and manage through challenges - people will lose respect and not trust your opinion. Another aspect of self-management (that ties into Self Awareness) is the ability to reflect and understand situations where you could have handled your emotions better.
Social Awareness	Persuasion; Empathy;	One of the areas in emotional intelligence is social skills. The ability to influence as an

	Influence; Navigating Politics; Understanding People; Understanding the Room; Understanding Personality Styles	engineering leader was discussed by many of the participants. One participant described influence as an outcome of having strong social skills, such as the ability to read a room and understand the tone/temperature of the room. Other participants described influence within software engineering as the ability to combine technical knowledge with the ability to communicate why the problem is worth solving - understanding how to socially relate and communicate in a way that people can understand. The engineering leaders discussed the value in studying and understanding people - paying attention to body language, ability to read people, understanding personalities - with many of them saying they wished they would have learned this as part of their engineering education - they get into the engineering world because it comes easy to them, but they have to learn the social aspects, which is harder for many engineers. Having these social skills leads to improving the ability to interact with others (connection with first theme). Part of understanding how to socially relate to others within the organization is understanding the politics, which leads to the skillset of navigating political waters - see memo under Navigating Political Waters.
Relationship Management	Ability to Interact with Others; Communication Skills; Relationship Building	he ability to interact with others was the biggest area in the human skills section. There are numerous components to this skill and various ways this skill can be used to be an effective engineering leader. Engineering leaders described the ability to be transparent when interacting with others such as being sincere and trustworthy and not having a hidden agenda. When working with their teams, the engineering leaders pointed out the importance of transparency because the team could see right through them if they were not being honest and upfront.

		Conflict resolution was identified as an important aspect of the engineering leaders role when interacting with their team and others within the organization. Multiple respondents described software engineering as a creative process that can be approached from many angles, which can lead to debates about how to solve a problem. In this case, the engineering leader's ability to ask questions (which was a key skill in the Technical Skill set to solve problems) and understand both sides of the story can help resolve the conflict. Numerous skill sets emerged when discussing how the engineering leaders interact with various people within the organization. When interacting with their teams, they identified key skills such as putting their employees first (using Servant Leadership) by being patient to enable and empower the team to help them grow. Many of the leaders discussed how helping the team grow by focusing on their personal development, personal relationships, and coaching can lead to stronger employee engagement. These skills of building a personal relationship were referred to as "managing the whole", meaning they take the time to understand what is going on with their teams at work and in their personal lives. Although this was identified as an important skill, some of the leaders admitted it was not their strength. When the engineering leaders discussed their interaction with their peers, different skill sets were identified (compared to the skills they use with their team). Various terms were used to describe how the engineering leaders worked with their peers, such as partnership and teammates. Overall, the engineering leaders agreed that having a relationship with their peers helped them be successful by sharing

		information, soliciting feedback, and understanding commonalities. Interactions with stakeholders within and outside the organization brought different skill sets to the table. One of the skill sets identified was being an interpreter - the ability to translate the customer's pain points into a technical solution and the ability to explain technical situations in a language that the customer can understand. Some of the other skills mentioned in this area was the ability to be reliable, open, and honest when interacting with stakeholders to help drive solutions. When discussing how the engineering leaders interacted with upper management, a common skill emerged - the ability to be brief and to the point by using crisp communication to provide the right level of information and ensure there is alignment in direction. Overall, the ability to interact with people at all levels within the organization became a key skill for engineering leaders - understanding how to tailor the communication and build relationships was tightly coupled with this skillset.
Critical Thinking Skills	Identifying Key Players; Negotiation; Decision Making; Asking Questions; Understanding the Why; Problem-solving	When discussing critical thinking skills, engineering leaders emphasized the ability to ask questions that will help the team think about a problem differently. Such terms as edge thinking, thinking outside the box, and big picture views were used when describing this skill. Asking questions leads to improved analysis of a problem. The engineering leaders described the importance of breaking down the problem, framing the problem, driving the conversation (which was also mentioned in technical skills), putting the pieces together, identifying dependencies, and creating a plan.

		Overall, defining the problem before jumping onto the solution
Business Acumen	Ability to Understand the Business	Some of the engineering leaders identified the ability to understand the business (e.g. business acumen or context) is an important aspect of being an engineering leader. This leads to the other skills such as influence, the ability to motivate people, employee engagement, and helping the team understand how they fit into the big picture. Understanding the business context also leads to more sound judgement when interpreting the needs of the business.
Strategic Thinking Skills	Architecture Direction; Big Picture; Forward Thinking	Strategic thinking included tactics such as positioning a solution as a win-win, thinking big picture and knowing where you want to go (architecture direction). Some engineering leaders explained how they used strategic thinking skills as part of their everyday role to ensure they were directing the team in the right direction. Some examples were creating architecture diagrams or figuring out ways to improve efficiencies. These tied back to the technical skills related to using a technical base to set a high level direction. Other engineering leaders said they do not use strategic thinking very frequently. Others described how their peers are too much in the day-to-day details instead of planning for the future and noted how these types of skills come into play when leading at the mid-level and above.
Ability to Encourage Innovation	Grounding Innovation in Reality; Fortuitous Interactions	All the engineering leaders interviewed noted the importance of encouraging innovation but indicated it must be done within the right context. For instance, focus on solving a real business problem and is grounded in current technology.

		The conceptual skill that comes into play with innovation is not the innovation itself - it is the skill of balancing innovation while continuing to meet the needs of the business. It goes back to looking at things from a strategic perspective to know how to make innovation valuable for the organization. Engineering leaders can encourage innovation by creating a safe environment, providing avenues for the team to participate in innovation activities (fortuitous interactions), and asking the right questions to spark new ideas. Many of the engineering leaders provided examples of how innovation is done within their organizations - initially these were coded as part of this section, but later removed because they did not have anything to do with the actual skill of encouraging innovation - they were the "what", not the "how". Encouraging innovation seems to be a combination of strategic thinking and critical thinking skills.

Appendix O.

Research Questions, Themes, Sub-themes

Table 24.

Research Questions, Themes, Sub-themes

Research Questions	Themes	Sub-themes
R1: How do engineering leaders describe the utilization of technical skills in their leadership positions?	Technical background can be utilized without involvement in technical details. Technical background can be utilized to solve problems and provide technical direction.	Using a Technical Base Transitioning Away from Details Setting High Level Technical Direction Problem-solving Skills
R2: How do engineering leaders describe the utilization of human skills in their leadership positions?	Emotional Intelligence skills are utilized to manage social awareness, self-awareness and self-management. Relationship management skills are utilized for effective communication and interaction with others.	Self-Awareness Self-Management Social Awareness Relationship Management
R3: How do engineering leaders describe the utilization of conceptual skills in their leadership positions?	Seeing the big picture based on strategic and critical thinking skills can be utilized to solve problems and drive direction. Encouraging innovation through the ability to create fortuitous interactions and understand the business.	Critical Thinking Skills Strategic Thinking Skills Ability to Encourage Innovation Business Acumen