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The Influence of Engineers on Public Policy

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ABSTRACT

THE INFLUENCE OF ENGINEERS ON PUBLIC POLICY

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Engineers play a vital role in society and contribute positively to economic growth in various areas, including energy, transportation, telecommunications, and others. In the United States of America, these areas are monitored by public policies that are set by policy actors—mainly lawyers, public administrators and social scientists—at legislative and regulatory levels. In these domains, engineers have a reduced voice with key decision makers on critical engineering issues, and their input is very limited. Their lack of involvement results in costly unintended consequences, affecting both the interest of the profession and the interest of the nation.

Research has shown that increased input from engineers bridges disciplinary gaps, allowing clarification of technical concerns and disentanglement of system complexities in public policy issues. This dissertation explores the skills necessary for engineers to navigate effectively within organizations and society, influence policy decisions, and the different factors impacting their influence. Grounded theory method is used to analyze data collected through semi-structured interviews conducted with engineers and other engineering or engineering management professionals. The investigation will lead to the construction of a theory and topic of study referred to as socio-political engineering. Furthermore, the perception of engineers regarding this topic of study is analyzed using a Q methodology, which supports the results of the grounded theory.

This knowledge provides insight into ways that socio-political engineering may enhance engineering education and engineers' certification through the development of capabilities to influence multidisciplinary decision making.

Key Words: Engineers, Public Policy, Influence.

This dissertation is dedicated to my family…

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CHAPTER 1

INTRODUCTION

The following chapter illustrates the rationale underpinning this research. It introduces the background of the investigated phenomenon, highlights the research gaps identified in the literature, and proposes the research questions and objectives. Furthermore, it emphasizes the importance of the study through a description of theoretical and managerial contributions. Finally, it outlines the structure of the report.

Background of the study

About a decade ago, the National Academy of Engineering (NAE) published a document entitled "The Engineer of 2020: Visions of Engineering in the New Century." As indicated by the title, the report revolves around the engineering role in the new century. One of the main suggestions made in this document was that engineers must participate and get more involved in the setting of public policy and the political domain because "technology [has become] ... progressively ingrained into every facet of our lives." (p. 7).

Engineering is a key engine of a growing economy. Since the 19th Century, various technological innovations have emerged, and they have driven profound changes in society (Meredith & McCarter, 2009). In fact, Engineers have been using their skills to operate systems, as well as to design and construct products that affect every aspect of life directly and indirectly. All these innovations, including the creation of roads, aqueducts, pumps, canals, electronics, and industrial developments, have fostered the economy (Wall, 2010) and brought changes to society. The following figure (Figure 1) summarizes the main branches of engineering (Hoiberg, 2000) and lists some of the contributions of engineers to society.

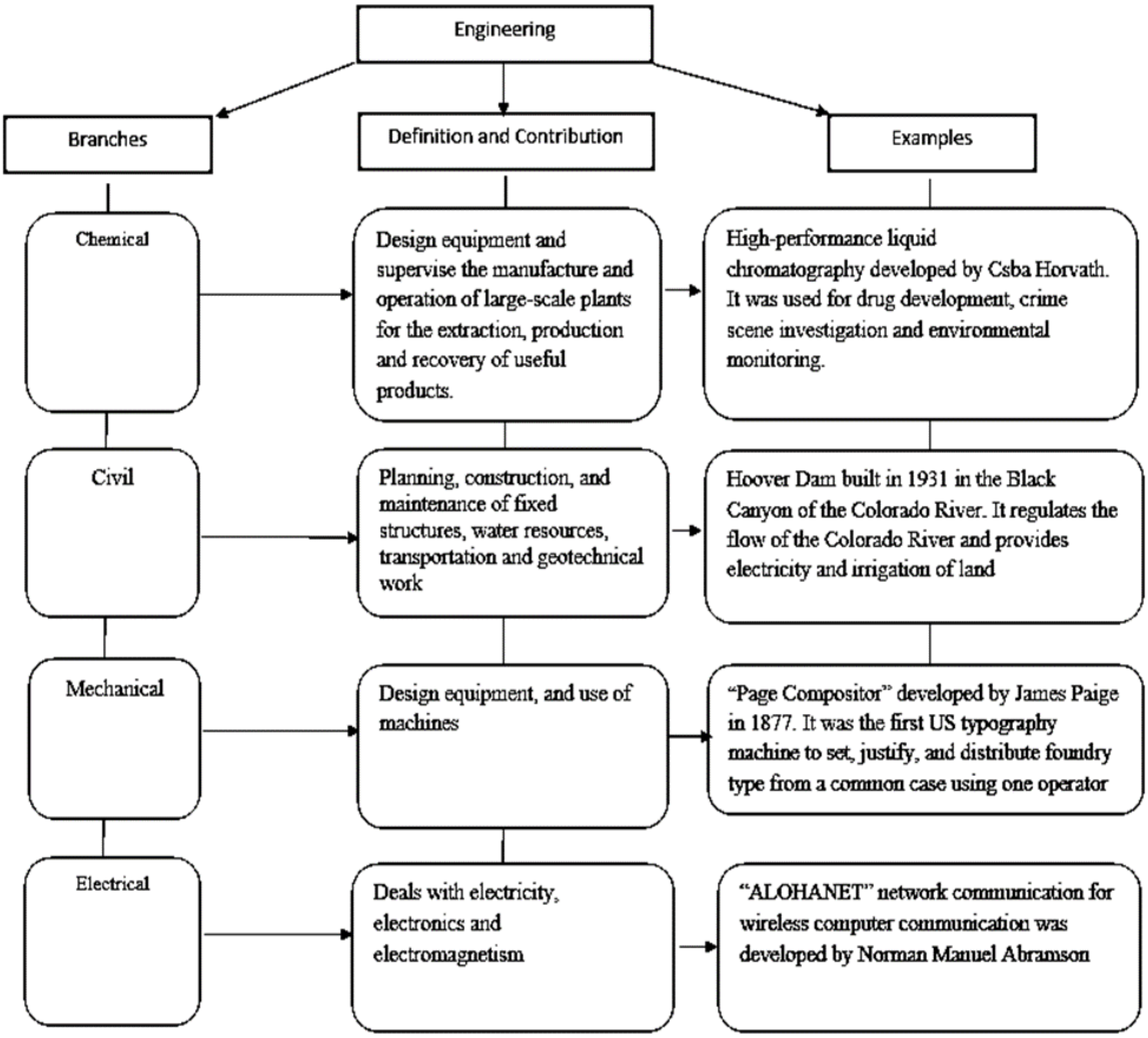

Figure 1: The main branches of Engineering and contribution of engineers to the society

The engineering profession tends to be held in a relatively low regard, politically speaking, when compared to other professions (Duderstadt, 2008). Typically, the principal actors involved in the political and public policy processes are lawyers and social scientists (Rhode, 2013; Denny & Robinson, 2003), while engineers and professional engineers have only limited exposure.

Historically, in the USA, two significant leaders with an engineering background who were involved in decision-making and public policy were Herbert Hoover and Jimmy Carter.

- Herbert Hoover was the first Engineer to be elected as president in 1929. To face the Great Depression, Hoover suggested the Hoover Dam project, which serves for multipurpose use, including the expansion of federal water reclamation projects, hydroelectric power, flood control and rapid city growth in the southwest (Dunar & Mcbride, 1993)
- Jimmy Carter served as the president of the US from 1977 to 1981. Under his leadership, Carter, proposed and established energy policy based on ten principles related to conservation, prices, and development (Carter, 1977). Furthermore, he was involved in various public decisions with an engineering dimension, which is related to foreign affairs. The Panama Canal treaty was one of the important decisions enabling the USA to improve their relationship with Panama and secure the canal (Skidmore, 1993).

Currently, according to the Congressional Quarterly Roll Call Guide to the New Congress at the federal level, only 8 members of the 114th Congress have educational backgrounds in engineering (Manning, 2015), while at the state level, only two governors have an engineering background (Flowers, 2002), which reveals the highly restricted involvement of engineers as a professional capacity. Mainly, the fact that engineers have always been tightly aligned with the industry is historically grounded. This fact has resulted from the inherent association that existed between local business and early land-grant colleges (Grose, 2009).

However, setting sound public policies requires further consideration of engineers' inputs. Lawyers and social scientists lack knowledge about the engineering profession and the complex technical issues that challenge society, as decision makers, they need to have a sound understanding of these complex systems and seek the help of engineers (Pivot, 2015). Specifically, engineers should influence public policy, not only in a private capacity as voting citizens but in a professional capacity (Casey, 2011), by advising the government, intervening at the appropriate time of the public policy process, providing relevant technical solutions, and contributing meaningful inputs that could lead to a better society.

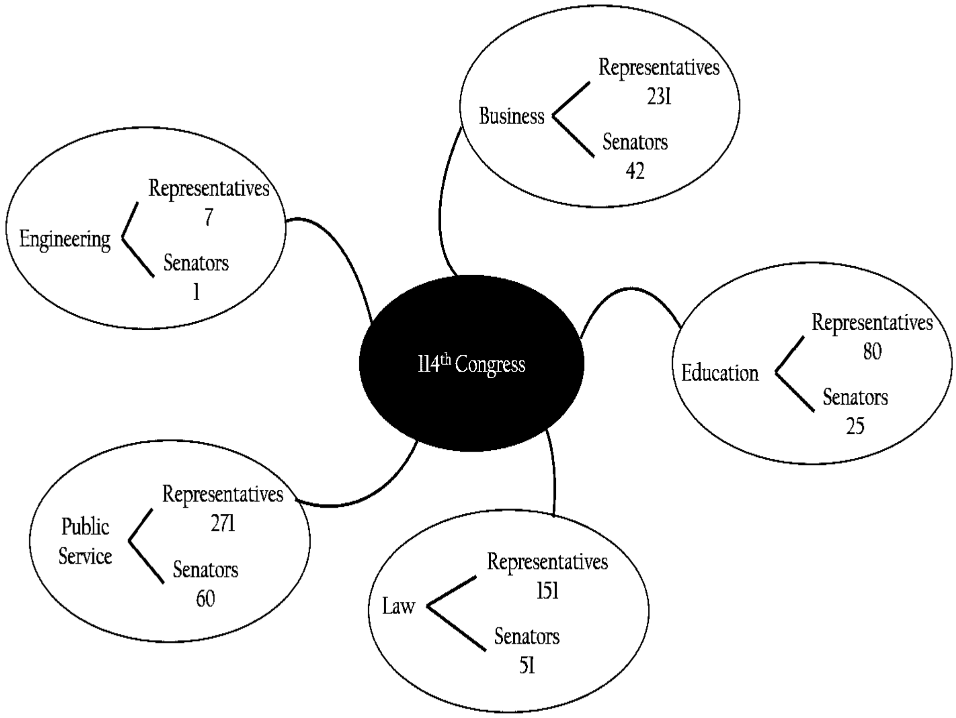

Figure 2: Members of the Congress by Profession

Statement of the problem

Society deals with many complex and ongoing issues including, but not limited to, climate change, underwater drilling, self-driving cars…etc. These issues have significant technical elements that necessitate a disciplined approach to their definitions, risk analysis, and optimal solutions. For instance, what are the engineering standards that need to be taken into consideration when setting policies for such issues? This is a very critical question as there are virtually no engineers or scientists participating in policies and decisions related to these phenomena (Augustne, 2011). Only non-technical-oriented individuals, who do not possess the required expertise and knowledge, carry out these tasks (Davis et al., 2002), and this may have detrimental effects on society.

Therefore, the participation of engineers is of utmost importance. By their qualifications, skills, and knowledge, engineers can provide sound analysis and solutions for these problems. They have the ability and the responsibility to get involved and intensify their influence on public policy to provide innovative and feasible solutions to the technological issues that society faces (Pivot, 2015). According to Owusu (2002), the World Federation of Engineering Organizations (WFEO) Comtech April – June 2002 issue stated: "…the professional engineer has the responsibility to advise the society on technology problems and to express his view on technical matters for providing support to the decision-making process." (p.4). Furthermore, Robert S. Walker, former U.S. Representative and former Chair of the House Science Committee noted that "engineers can positively influence the policy process by openly and publicly enunciating the role." (Galloway, 2007, p.75) Their practical advice and input are vital to enhancing the quality of the decisions made at the different levels of the government, particularly to set efficient public policies.

Specifically, several attributes make engineers critical to public policy making. First, engineers are well trained about critical analysis of problems; they can analyze problems using rational and systematic methods. Second, they have the interdisciplinary background including business, public health, and technology, and hence are explicitly cognizant of the activities required to sustain a quality of life. Third, they vow moral and ethical obligations to protect the health safety and welfare of the public (Wall, 2010). These characteristics make engineers ideally suited for advocating solutions to problems faced by society.

Consequently, if engineers are at the apex of politics and policy-making related to technological innovations provided to society, public welfare would be maximized (Galloway, 2007).

Research questions

Research questions were developed to address the problem conceived in the initial literature review. The research seeks to define and articulate sociopolitical engineering and how is it used by engineers to influence public policy through the exploration of the following research questions: (1) What are the constituent elements of sociopolitical engineering, and what attributes and dimensions characterize these elements? (2) What framework can be developed for constructing and articulating sociopolitical engineering? (3) What are the engineers' perceptions about their influence on public policy?

Specific research sub questions that can be asked herein include:

- Why engineers should get involved and intensify their influence?
- What are the key concepts that relate to engineers' participation in the public policy process?
- What are the main factors that affect engineers' influence on the Public Policy process?
- What is the perception of engineers about the framework?
- What are the inter-relations and similarities between the engineers who participated in this study?

In answering these research questions, the participation of engineers in the public policy process will be explored. Factors influencing the involvement and effectiveness of the public policy process are also of relevance.

Hypotheses

The research questions proposed are exploratory in nature and require no hypotheses-test, but hypothesis generation. The grounded theory will be used as a methodology, allowing the researcher to begin the research without formulating hypothesis at the beginning.

The first and second questions will be answered using theoretical coding and propositions will be developed from the interviews.

The third question will be answered using Q method, which is also an exploratory method (Watts &Stenner 2005, Durning & Brown 2007) and does not require hypothesis testing.

This being written, the results of both theoretical coding and Q analysis will not be interpreted to confirm or reject any hypotheses, but to generate a theory (Auerbach & Silverstein, 2003) and analyze the interrelation between/among the complex answers of the participants (Watts &Stenner 2005), respectively.

Purpose of the study and research contributions

In the seminal report, ‘’Engineering for a Changing World: A Roadmap for the Future of Engineering Practice, Research, and Education [the Millennium Project, The University of Michigan 2008],’’ Dr. James J. Duderstadt stated, “The absence of engineers from either the leadership roles of business and government or the primary debates over the problems of our times poses a significant threat to society in an increasingly technological world.” (p. 56). The need for engagement and involvement by professional engineers is of great significance for setting sound public policy and monitoring complex technical issues in the society. In this research, the focus will be on the exploration of how engineers can influence decision-making and public policy.

This research uses a constructive grounded theory and a theoretical framework M-O-A to guide the inquiry. Based on the well-known Motivation-Opportunity-Ability (MOA) framework, a successful involvement of engineers needs to have three factors: motivation, opportunity, and ability. So far, most research bridging the gap between engineering and public policy has focused on opportunity and ability. Studies of opportunity seek to shed light on the possibilities offered to engineers to get involved in public policy, for instance, advocacy (Kilpatrick 2000), while studies of ability seek to investigate the capabilities engineers need to participate in public policy making. For example, communication (Tull & Jones, 2006; Myers & Stuart, 2010), and interdisciplinary work (Russell, Marshall, & Tramba, 2006) have been considered as major elements contributing to engineers' ability in participating in public policy. To date, the motivation factor, understood as the extent to which persistent effort is directed toward a goal (Nader, 1988), remains largely unexplored. Up to now, far too little attention has been paid to the role of engineer's motivation in their influence of public policy. Although some scholars have alluded to issues that can decrease an engineer's motivation, empirical analysis of this topic is lacking. For instance, Galloway (2007) contends that the uncomfortable feeling to stand up and speak out on public policy issues holds back engineers in the public policy process. When discussing power, it is the ability to influence a decision based on the position a person has in the government (Greenberg, 2011). In the United States, certain decisions, such as making treaties, and signing bills, are influenced by the President because of the office. And, unfortunately, as it was stated previously, a very small number of engineers hold positions as public decision makers.

Despite these previous studies, there is no empirical study that explores these factors, namely, motivation, ability, and opportunity. Specifically, this study was motivated to answer the following research question: What drives engineers to do a transition into politics, and influence the decision-making process?

Mostly, this study contributes to the literature in three important ways. First, it bridges the gap between engineering and public policy-making research. Second, the study extends the use of the MOA framework to a novel context by focusing on engineers' influence on public policy. This framework will be used to map the grounded theory and answer the research questions; therefore, it leads to the construction of a theory and topic of study referred to as socio-political engineering. This will contribute to the research methodologies in engineering management where grounded theory is currently of limited use. In fact, inductive research should be improved in areas related to engineering management, such as decision-making and complex systems issues.

Lastly, this knowledge will provide insights into ways that socio-political engineering may enhance engineering education and professional engineering certification through the development of capabilities to influence public decision-making. Research in socio-political engineering will enable researchers to address problems where knowledge of technical details and engineering principles is critical to decision making.

Method and procedure

This study is rooted in a post-positivist philosophy, which has implications for the methodological choices adopted by the researcher. The grounded theory (GT) was selected for this research because of the alignment between the GT approach and the research purpose. Given that there remains ambiguity around the "how" and "what" questions related to engineers' influence on public policy, and that this research is looking for a richer exploration process with the objective being a theoretical construction, GT was considered an appropriate approach. Moreover, the researcher's philosophical perspective was in line with taking a qualitative view of the phenomenon under study.

Following the philosophical stance adopted in this research, the GT is particularly relevant because, although it contains positivistic elements, the proper use of GT suggests the researcher must be able to understand various perspectives and to be able to construct reality through the interpretation of those perceptions, which is in line with the subjectivist epistemological stance of the researcher. However, the study does not seek active intervention, but rather the investigation of the phenomenon in its natural settings (Gummesson, 2000). Consequently, a high level of objectivity is needed to reduce researcher bias and ensure that the perceptions of actors involved in the phenomenon were gained effectively.

The sampling process will be based on theoretical sampling, which means that the researcher selects an initial case, and on the basis of the data collected and the emerging theory, they select additional cases. The theoretical sampling process will continue until the point of theoretical saturation, when no further categories are emerging, in order to obtain a full deep coverage of the data (Glaser & Strauss, 1967). Accordingly, data collection and analysis are interrelated processes. In this study, semi-structured interviews will be conducted with professional engineers and other engineering or engineering management professionals. This will provide flexibility to dig deeper into a question and ask for explanations when the answer is vague, as well as to get the respondents to expand upon their answers and to add additional perspectives as needed (Saunders, 2011).

Once the theory was generated, the research followed the Q method to determine the perception of engineers on the theory's components.

Chapter summary

The chapter has explained the purpose of this research by stating the problem, the background of the study, developing research questions, and discussing briefly the method used. It also highlighted the anticipated research contributions. The study is structured as follows (Figure 2). In Chapter 2, the literature review will address the state of the field and list what other scholars have written in relation to this topic. Next, the research method will be described in Chapter 3. This third chapter highlights the methodology adopted. The fourth chapter presents the findings of the data analysis. Chapter 5 discusses the results of data analysis and theory development, and Chapter 6 represents the conclusion and recommendations of the dissertation. Figure 2 demonstrates the structure of the dissertation.

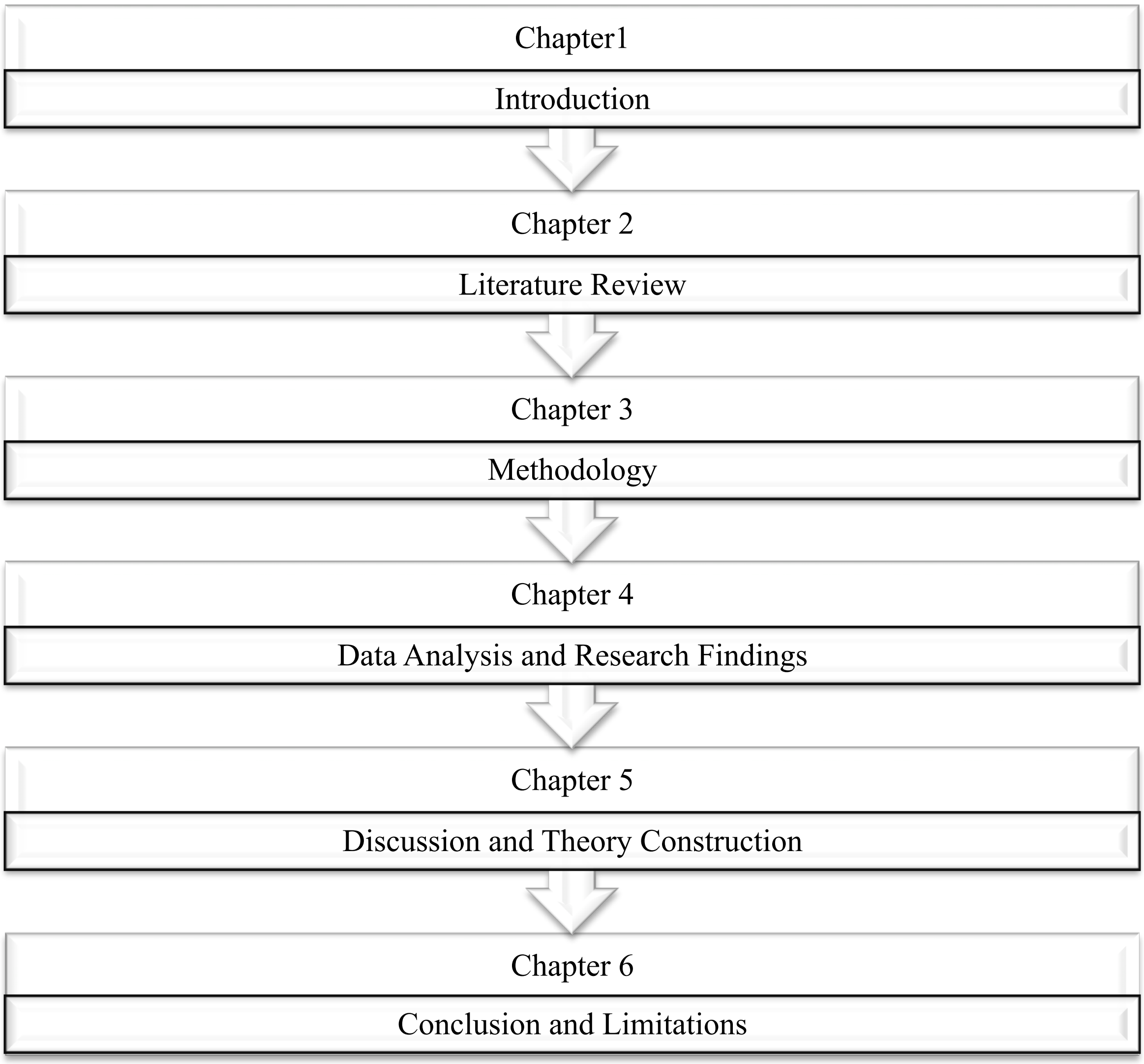

Figure 3: Dissertation Flow Figure

CHAPTER 2

LITERATURE REVIEW

This chapter is dedicated to discussing the background of the study and understanding the fundamental concepts to an appropriate analysis of engineers' influence on public policy.

Main Concepts

Difference between public policy, political engagement and public decision making

Dean Kilpatrick (2000) defines public policy as "a system of laws, courses of action, regulatory measures, and funding priorities concerning a particular topic promulgated by a governmental entity or its representatives" (p.3). Public policy may also be viewed as "an intentional course of action followed by a government official or institution for solving an issue of public interest'' (Cochran, Mayer, Carr, Cayer & McKenzie, 2015, p 1). Also, Mayers (2007) includes in his definition that public policy involves the government, as well as the interpretation of its positions by "various stakeholders."

Public policy is different than political engagement, where political engagement is defined as an "activity that has the intent or effect of influencing government actions" (Verba, Schlozman, & Brady 1995, p10). This engagement takes different forms, such as voting, lobbying, participating in the political discussion (Conway, 2000). On the other hand, the concept of "public policy'' refers not only to the outcome of policies, but also to the decision-making and the analysis of the series of actions taking place on multiple levels and affecting the daily lives of citizens (Mayers, 2007). These public decisions are made after the interactions within a group, including Congress, the President, the Cabinet, advisors, agency bureaucrats, federal and state courts, political parties, interest groups, etc.

Distinction between influence and participation

Influence is defined as the potential to affect the behavior of others in an intended direction (Cohen, Morgan, & Pollack, 1990). To have an impact on public policy means efficiently participating in shaping decisions and providing better guidance for better policies. Policy influence is defined as "an intervention intended to catalyze, stimulate, or otherwise seed some form of change through different forms of persuasion" (Tsui, Hearn, & Young, 2014, **p.10)**.

Robert Beno Cialdini developed the theory of influence based on the principles of reciprocity, commitment and consistency, social proof, authority, and scarcity (Cialdini, 1993), explaining persuasion. In politics, Gaventas &Valderrama (1999) referred to the engagement in local government as participation.

Existing definitions of participation reflect this range of perspectives from the very broad "participation is genuinely feeling part of something" (Eve Bevan, Shepherds Bush Healthy Living Centre), to the more specific view that participation is the "efforts that people make in order to influence public policy decisions" (Gerry Stoker, Manchester University). An older definition by the United Nations Research Institute for Social Development (UNRISD), cited by Mango (2015) describes participation as "the organized effort to increase control over resources and regulative institutions on the parts of groups and movements hitherto excluded from such control" (p.1). In this study, the researcher will be using the three concepts interchangeably.

Public policy process influence

Various factors drive actors, including engineers, to impact the development of public policy. These factors are presented in the next section.

Factors of influence

Scholars have identified various factors that can affect public policy. Goldfeld (2000), Kingdon (1995), and Moore (1995), adopted the knowledge broker sphere of influence. Kingdon (1995) argues that influencing decision-making necessitates the combination of the following: recognition of an issue, identification of possible solution, and political commitment. Moore (1995) supported this by adding that sound policy requires capabilities, public value, and authority. His study focuses more on how to narrow the policy goal by sharing information and adequate knowledge with decision-makers to make evidence-based decisions. In the same line, in another article, Martin, Goldstein and Cialdini (2014) stated that factors of influence are linked to changing perceptions and behaviors which are related to human motivations

Arabi (2014) pointed out that affecting public decision-making is related to power, advocacy, and policy competence. As policy actors, engineers have the necessary skills and attributes to influence public policies. In fact, armed with knowledge covering an array of subjects such as technical systems, sciences, social behaviors, and many others, engineers may use the appropriate methodologies for complex systems and system analysis to support different stages of the policy process. These stages include problem formulation and problem exploration, as well as responding to the various technical issues that exist. In fact, engineers may introduce methods that are useful to the public policy process, for instance, means-ends analysis, causal maps, and system diagrams (Hermans & Thissen, 2009).

Various opportunities are offered to engineers to participate in public policy, called strategies of influence

The strategies of influence

Public policy can be influenced by an internal or external setting through a variety of procedures including but not limited to, consultation, voting, and advocacy.

Consultation could be described as a way of getting advice on a specific issue (Webster, 1995). Within the context of public policy, consultation is a communication process between the government and other stakeholders (Craythorne, 1997). Accordingly, it is a type of participation that can occur through various means to influence public policy (Benwell, 1980).

Voting, by definition, is a process through which individuals elect a political party to become policy maker. It is a right that US citizens exercise to participate in politics (Conway, 200). Public policies do not emerge out of the votes but out of the interaction of the elected candidates.

Advocacy is described as the attempt to influence public policy through education, lobbying, or political pressure (Kilpatrick 2000). Engineers can act as an advocacy group to educate public policy makers about the existing issues, their nature, and the legislation needed to address them. In the U.S., engineering societies do not invest much in political advocacy. According to some statistics provided by the National Society of Professional Engineers, the organization spends $300,000 a year, while the other engineering societies invest almost nothing in advocacy. Compared to the inputs of the other interest groups, the participation of the engineers in public policy through advocacy is limited.

For the government, these different strategies are external sources. Since their adoption is expensive, government departments should ensure they have sufficient in-house engineering capable to act effectively.

Public policy process overview

Public policy process models

This public policy process is complex and to understand it there are various models (Cockrel, 1997), are summarized in the following table. The first two models focus on who makes the decisions, while the other two discuss the decision process. Kings and kingmakers are an elite model of public decision-making where specific people have the power to take the decision, regardless of their ability to make significant technical arguments (Birkland, 2014). The iron triangle represents the relationship groups including Congress, bureaucrats, and special interest groups. This triangle is used to describe the role of each group and the action is undertaken to help the others. The rational, comprehensive model is a theoretical model

Models	Specifications
Kings and Kingmakers	Focus: Who has the power? Elites: public administrators and politicians Use: Explain the role of leaders who influence public policy
Clusters Iron Triangle	Focus: Who has the power? Groups Use: Describes the central role of groups who has means to influence public policy
Rational-Comprehensive	Focus: How are decisions made? (Rationally, comprehensively) Use: Highlights how decisions are made.
"Muddling Through"	Focus: How are decisions made? (Incrementally) Use: Discusses how officials make their decisions

Table 1: Public Policy Process Models

presenting how public policy decisions are made (Hostovsky, 2006), and it is based on an in-depth analysis of every policy option available which even though it is dominant, it is criticized (Lindblom, 2018). Lindblom suggested “Muddling Through” which is to some extent a more process of "successive limited comparison," where policymakers do not process all policies but the ones that are slightly different than the current one which decreases the alternatives in question.

Each one of these models has limitations. The researcher will not adopt any one of these models, but discuss the role of engineers within the public policy process by combining these models.

Public policy process steps

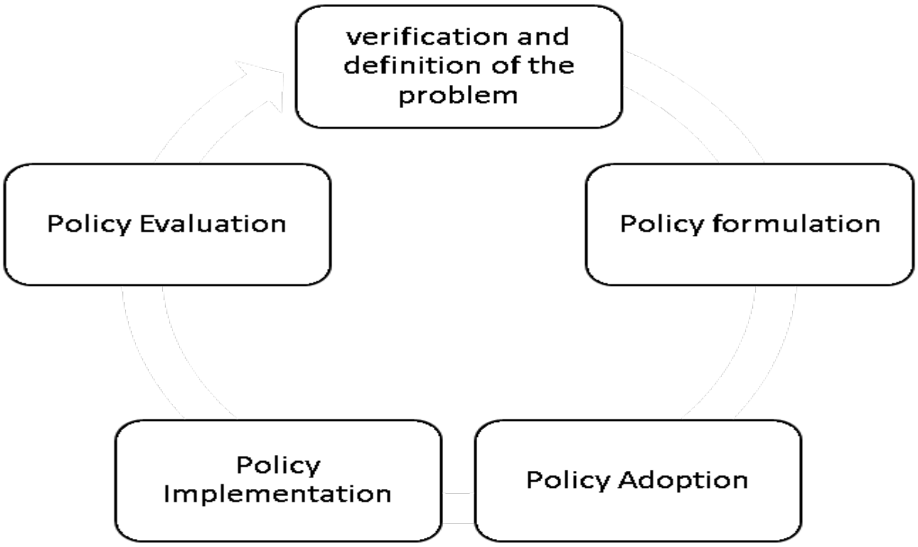

Figure 4: Public Policy Process (Dunn, 2015)

The development of public policy is an iterative process that is shaped based on different stages. The notion of the public policy process is originated from system theory as conceived by David Easton (1965). Brewer and deLeon (1983) described the policy cycle in multiple stages, which include: initiation, estimation, selection, implementation, evaluation, and termination. Similarly, Dunn (2015) based his understanding of public policy process on different stages. The first stage is the emergence of a problem, the second one is the recognition, and definition; then he progresses to setting an agenda, where alternatives are developed; followed by adoption; then implementation; and finally, the evaluation. This policy process is considered to be "fluid, incremental, confused, often disorderly and even incoherent" (Bone, Hart-Nibbrig, Pealy, & Anschell, p. 4).

Problem identification

Problem identification is the first step of the public policy cycle, where issues are expressed by various participants based on their need or dissatisfaction such as pollution issues or water quality problems (Dunn, 2015). This problem should be perceived as necessary by the government to take place on the Agenda and find solutions as well as implement changes. This decision should be supported by engineers' and scientists' data and expertise (Vance, 2005).

Policy formulation

Public policy is formulated within the agenda-setting stage. At this level, the media plays a role in a way that it helps social construction related to environmental quality but not the environmental issues and causes (Barkenbus, 1998). These issues and purposes should be discussed by experts, including engineers and scientists, who unfortunately do not play a vital role, as Dearing and Rogers (1996) stated that "scientific research findings do not play a vital role in the agenda-setting process." (p. 91). Thus, Healey (1992) recommends within the planning phase a "communicative conception of reality, to replace that of the self-conscious autonomous subject using principles of logic and scientifically formulated empirical knowledge to guide actions." (p. 239). In fact, if the role of engineers is more potent, then the identification of risks will be of high concern (Barkenbus, 1998).

Policy adoption

For the government to adopt a policy, a construction of a majority coalition supporting it (solution to the identified problem) should take place. This adoption is influenced by different policy actors, namely individuals, institutions, and agencies (Mohanty & Mohanty, 2014), through their beliefs and their values.

Policy evaluation

The implementation of public policy is the last stage of public policy cycle that is not taken into consideration appropriately (Barkenbus, 1998). For instance, in ecological systems, according to Davies and Mazurek (1998), technical evaluations are rare but not absent for all environmental policies, and when they were conducted, decision makers ignored them. The reason behind neglecting the evaluation stage is the fact that decision-makers evaluate decisions targeting positive results for political purposes only.

Finally, in the course of this continuous process, on local, state, or federal levels, several entities interact to implement and formulate public policies that serve the public. As public policy actors able to act on or exert influence on a decision (Enserink et al., 2010), engineers should help to improve this process by providing unbiased and robust propositions based on active engineering approaches for problem-solving and risk assessment, their input and influence should take place and be available in the all stages as needed (Vance, 2005).

Engineers' responsibilities and leadership

Engineering profession: definition

The term "engineering" is defined by the Accreditation Board for Engineering and Technology as " the application of the mathematical and natural sciences knowledge gained by study, experience, and practice to develop ways to use the materials and forces of nature economically for the benefit of mankind" (page 1). Engineers play a primordial role in society. The practice of engineering refers to "any service where the methods and principles of engineering are used including consultation, evaluation, investigation, and design of public or private utilities, machines, structures, equipment, processes, transportation systems and work systems" (Section 32.1-163.5 Administrative Virginia Code). This implies that engineers are involved in numerous fields that contribute to economic growth and lead to a better society. However, the policies and laws of these fields are set by policy decision makers from different educational backgrounds with the exclusion of engineers, whose participation and influence are necessary.

Responsibilities of engineers

Engineers play different roles in society, which carry ethical challenges requiring the definition of engineers' responsibilities. Through the engineering profession's code of ethics, an essential guide to professional conduct, engineers, in general, have an ethical obligation (Johnson, 1989) concerning society, employers, clients, colleagues, the engineering profession, and himself/herself (NSPE Code of Ethics). Thus, this is a micro-ethical responsibility that concerns only personal relationships between individual professionals (Ladd, 1980) and disregards the macro-ethical responsibility that affects the members of a profession as a group in their relation to society. From Macintyre's (1984) viewpoint, an engineer's responsibility should be defined by the nature of the practice of engineers. The authors suggested that engineers are responsible for learning the standards of excellence representing the engineering profession and ensure that those standards are respected. Moreover, engineers should advance those standards by identifying and solving the problems faced by the practice. Finally, engineers need to have a broader view of their profession and its related decisions, in a sense that they should work on the problems inherited from the past and work toward the solution of current and future issues.

In fact, these are the responsibilities that come into play when participating in public decision-making. Accordingly, engineers shoulder the responsibility for not only their work but also for individuals' lives that are affected by that work. Complementary to understanding their responsibilities, engineers should possess strong leadership ability.

Engineers' leadership

The concept of leadership was initially introduced by Burns (1978) and was subsequently applied in organizational management by various scholars. It is defined as "the process of impacting others to agree about what needs to be done and how to do it, and the process of facilitating individual and collective efforts to accomplish shared objectives" (Yukl, 2006, p. 8). Over time, various leadership theories have emerged including, Trait theories (Colbert, Judge, Choi & Wang, 2012), behavioral approaches, contingency theories, and power and influence theories. Engineers use these different theories to lead teams across organizations (Rottmann, Sacks, & Reeve, 2015).

Towards a change

The rationale behind integrating engineering leadership in public decision-making is developing a clear vision and enhancing performance (Cropf, 2008). In the context of engineering and public decision making, leadership is crucial, as it has become necessary to make changes in an environment where there is growing interdependence between technology, society, and public policy. Accordingly, this change can only come about if engineers take an active role and assume leadership positions (Clough, 2004) by possessing leading main change features (Yukl, 2002). Engineers should maintain some capabilities including risk assessment ability, the willingness to take initiatives, resourcefulness, and flexibility to deal with uncertainty and overcome obstacles or constraints, as well as trust and loyalty in a team setting (Batool, 2013). Possessing those capabilities will enable engineers to develop and communicate the vision for the future and to help shape public policy. In this regard, Wakeman (1997) listed the various practical leadership roles that engineers can play in the different steps of the public policy process, including vision clarification and enhancing performance.

Furthermore, Dump (2008) suggests that engineers should become imbued with the functions and relationships of various stakeholders involved in the decision-making process. These stakeholders include the Governor, legislature, the judiciary, local governments, and interest groups, and engineers are likewise required to be able to formulate effective strategies to balance their interests, and simultaneously be consistent.

Implementation of risk-informed approach within decision making

This section explores how engineers can participate to make the appropriate risk-informed decisions.

Overview of risk perception

Risk is an inescapable part of every decision. Sometimes these risks are minor, while sometimes they have considerable implications. Pinto, Magpili, and Jaradat (2015) define risk as “future event with undesirable consequences without specific regard to intent” (p.2). Multiple factors influence risk perception including the following:

- knowledge (Science Communication Unit, 2014), where risk is estimated based on the occurrence probability and consequences (Pinto & Garvey, 2012; Bouder & Beth, 2003)
- cultural background (Science Communication Unit, 2014)
- gender (Slovic, 1999; Ballou &Biggs, 2010)
- ethnicity (Ballou & Biggs, 2010)

- learned behaviors (Brewer, 2005)
- the characteristics of risk (Bickerstaff, 2004) in which either the risk is voluntary or involuntary (Brewer,2005; Fischhoff, Slovic, Read,& Combs, 1978), controllable or uncontrollable (Fischhoff, Slovic, Read,& Combs, 1978)
- political factors (Ballou & Biggs, 2010)
- psychological factors (Science Communication Unit, 2014; Asveld &Roeser, 2012; Ballou & Biggs, 2010)

Public risk perception and benefit

Alhakami and Slovic (1994) explored the relationship between the public's perception of risk and the benefits of it. They used two different measures - correlation and distance - to prove the existence of an inverse relationship between risk and benefit. This relationship is explained by the "affect" of the risk's evaluation (Alhakami & Slovic, 1994; Slovic, 1999; Poortinga & Pidgeon, 2005), implying that judging or evaluating risks of an activity or a technology is based on the public's emotions and feelings. As researchers point out, "If their feelings toward an activity are positive, they judge the risks as low and the benefits as high. However, if their feelings toward it are negative, they tend to judge the opposite— high risk and low benefit" (Slovic, Finucane, Peters, & MacGregor, 2004, p.315).

In the context of public decision-making, perceived risk and benefit are related to trust (Earle, Siegrist, and Gutscher, 2001), public perceives risk as low if they trust decisions makers, and believe they are qualified to make appropriate decisions.

Effect of risk perception on public policy

The principal actors involved in the political and public policy processes are lawyers and social scientists (Rhode, 2013), which implies that regulations and decisions are taken by individuals who lack technical knowledge and analytic skills. Furthermore, those actors consider the public perception of risk in their decision making, which may lead to biases and tendencies (Tversky & Kahneman, 1974; Sunstein, 2005) as those perceptions are subjective and profoundly impacted by affection. Slovic (2004) explained the “heuristic affection” reaction by the deliberate manipulation, or/and the limitation of this affection. Accordingly, a risk is mostly evaluated based on the experiential system.

In the context of public policy, risk perception is not related to cognitive biases (Sjöberg, Moen, & Rundmo, 2004). The involvement of professional engineers, with sound knowledge of technology, systems, risks analysis, is of utmost importance. In fact, they will influence public decision-making based on experiential and analytic methods. The integration of both systems is necessary for a rational decision-making (Slovic, Finucane, Peters, & MacGregor, 2004).

Role of engineers in setting risk informed public policies

Risk-informed decision-making refers to “a deliberative process that uses a set of performance measures, together with other considerations, to inform a decision (Zio & Pedroni, 2012, p4).

The following graph shows the process of informed decision making.

Figure 5: Risked Informed Decision-Making Process

The first step "Identification of Alternatives" is qualitative where the different issues are listed as well as alternatives are suggested by different stakeholders (Stamatelatos, Dezfuli & Apostolakis, 2002)

The second step reflects the quantitative measurement of alternatives where risks is taken into consideration. In this regard, armed with a cumulative knowledge, both technical and ethical, engineers may play vital roles in building dependable decisions and risked informed public policy. They may improve risk assessment, risk management, risk communication and provide a better risk analysis to risk-informed public policies.

Figure 6:Risk analysis, risk assessment, and risk management are necessary for an effective risked informed public policy

Risk analysis

In risk-informed public policies, engineers may play a role in risk analysis by listing the potential failure modes, the risk occurrence frequency that may be the cause of the failure, the structural performance, and the adverse consequences (FEMA, 2015).

Risk assessment

Risk Assessment defines risk based on probabilities and outcomes, taking ethical considerations into account (Asveld & Roeser, 2012). During this process, professional engineers may provide frameworks for the quantification of the risk likelihood and the scientific interpretation. Using different techniques, from failure modes, effect analysis, to the theoretical level of human exposure (Bouder & Beth, 2003), engineers can analyze the system as a socio-technical system and contribute by making recommendations to influence the decision-making process and formulate sound public policies (FEMA, 2015).

Risk management

Risk Management in public decision-making implies having the capacity, not only to identify the nature of risk, but also to find appropriate responses (Bouder & Beth, 2003) as well as list risk reduction options (FEMA, 2015). Various tools are available to reinforce the implementation and execution of risk management, including the Preliminary Hazard Analysis, Hazard, and Operability Analysis, Job Safety Analysis, Failure Mode and Effects Analysis, Fault Tree Analysis, and Cause and Consequences Analysis (Pinto et al., 2015). Professional engineers may use these techniques to play a vital role in effective risk management.

Engineers, experienced and knowledgeable in risk management will be able to identify risk, analyze it, prioritize it, develop it, and assure that risk information is well communicated (Dorofee, Walker, Alberts, Higuera, & Murphy, 1996).

The Heuristic effect is of considerable influence in personal decision-making as well as public decision-making, which may lead to illogical decisions. An integration of two systems “experiential and analytic” is necessary for a dependable risk-informed public policy.

Engineers can use both methods, which makes their role important in setting effective and efficient risked informed decisions, as well as gaining public trust within and through the government.

Chapter summary

In this chapter, the researcher discussed a literature review. This literature addressed the state of the field and listed some of the essential scholarly works related to this topic. It explained the fundamental concepts, highlighted the limited role of engineers on policymaking, and explicated the difference between a government decision and a risk-informed decision, where the role of engineers is essential.

CHAPTER 3
METHODOLOGY

The previous chapters introduced the research question discussing it in the context of the associated literature review. The objective of this chapter is to examine the philosophical and methodological considerations for answering the proposed research question.

Research philosophy

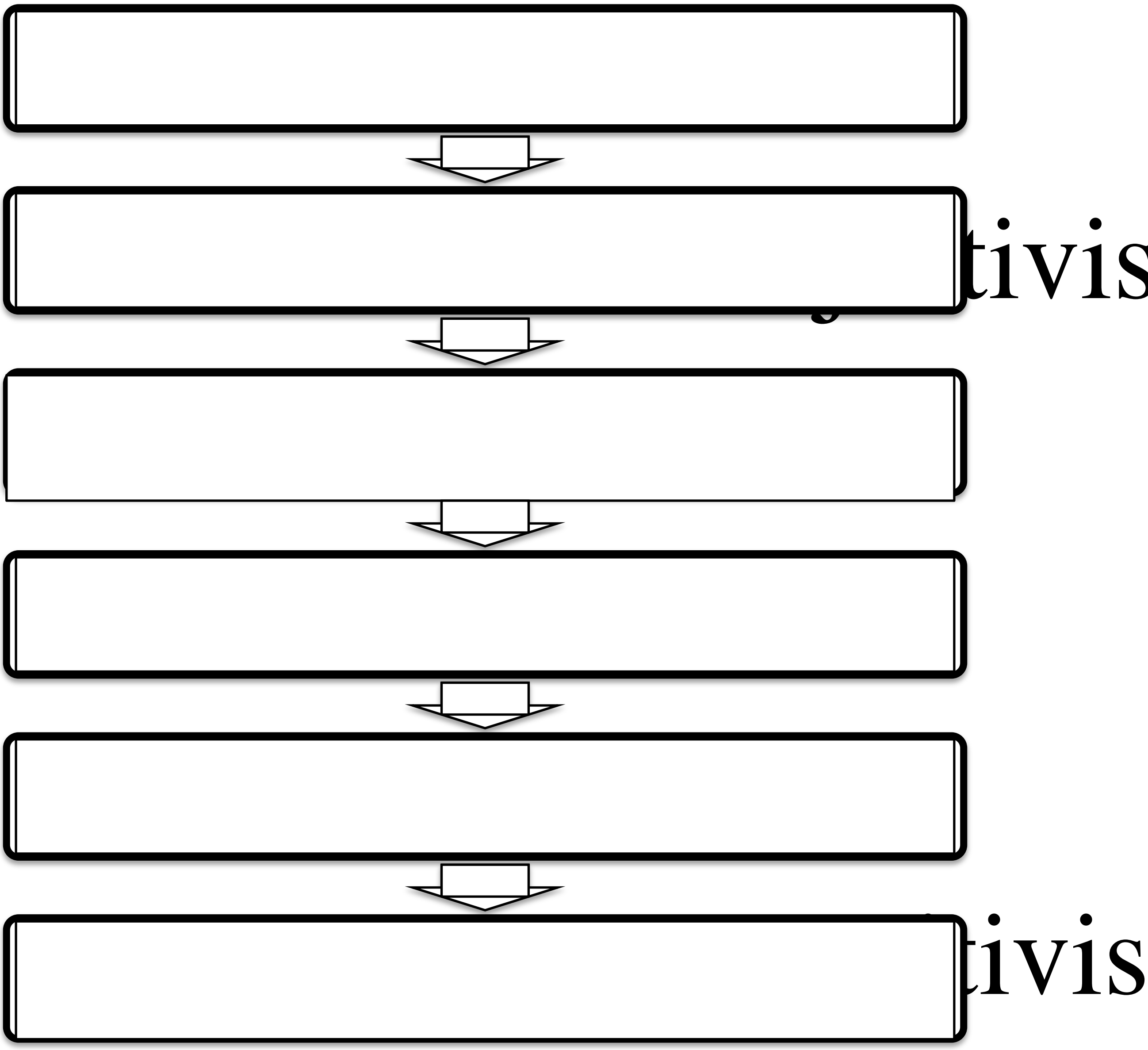

Figure 7 The Different Elements of a Research Design

Several factors influence the choice of research design including the research objectives, the extant literature and the philosophical and paradigmatic positions (Gummesson, 2000). Figure 7 illustrates the different elements of research (Saunders, Saunders, Lewis, & Thornhill, 2011).

The objective of this section is to establish ontological, epistemological, and methodological bases that underpin this specific research endeavor.

A research philosophy or paradigm is a central concept in scholarly research. It is defined as the underlying belief system that guides the researcher, not only in terms of methodological choices but also in ontologically and epistemologically fundamental ways (Guba & Lincoln, 1994). Thomas Kuhn's seminal work “The structure of scientific resolutions” (Kuhn, 1970) was mostly the essence for popularizing the term paradigm. Researchers have consistently emphasized the importance of the research philosophy in guiding research projects. Denzin and Lincoln (2000) stated that all researchers approach the world with a set of abstract beliefs related to ontology, epistemology, and methodology. Similarly, Sutherland (1973) emphasized that “the research philosophy is the premise under which investigation, analysis, and model-building take place – in effect, they are what we might loosely refer to as transparent axiological predicates of the scientific enterprise.” (p.56). Mainly, a research paradigm influences the way knowledge is studied and interpreted, it impacts the way theories are created and tested (Miller & Tsang, 2011), and consequently it facilitates the choice of appropriate research design (Blumberg, Cooper, & Schindler, 2014).

Burrell and Morgan (1979) presented a well-articulated philosophical schema that applies to various research areas. The authors argue that distinction between paradigms is based on ontological, epistemological, methodological, and human nature assumptions (Burrel & Morgan, 1979). Figure 1 represents these dimensions as developed by Burrell and

Morgan (1979). First, ontology is concerned with the nature of reality. It is defined as "the claims or assumptions that a particular approach to social inquiry makes about the nature of social reality claims about what exists, what it looks like, what units make it up and how these units interact with each other (Blaikie, 1993, p.3). Second, epistemology is related to the way knowledge is created. It is defined as "the claims or assumptions made about how it is possible to gain knowledge of this reality, whatever it is understood to be, claims about how what exists may be known" (Blaikie, 1993, p.7). Third, assumptions concerning the human nature explore the relationship that exists between individuals and their environment. Finally, Burrell and Morgan (1979) argue that assumptions regarding ontology, epistemology and human nature determine methodological assumptions for research, which in turn guide how the researcher discovers knowledge. These four assumptions form a continuum between two extreme or overarching paradigms: the subjectivist and objectivist approaches.

The table below (Table 2) summarizes the positions within those assumptions.

Philosophical assumptions	Dimensions	
Ontology	Realist	"The social world external to the individual cognition is a real world made up of hard, tangible and relatively immutable structures " (Burrell & Morgan, 1979, p.4) → Reality is objective, and individuals do not significantly impact on what is being observed.
	Nominalist	" The social world external to the individual cognition is made up of nothing more than names, concepts, labels which are used to structure reality " (Burrell & Morgan, 1979, p.4)

		→ Reality is the product of an individual's minds and can therefore be interpreted in various ways.
Epistemology	Positivism	Knowledge is determined through "regularities and causal relationships between its constituent elements…The growth of knowledge is essentially a cumulative process in which new insights are added to the existing stock of knowledge and false hypotheses eliminated" (Burrell & Morgan, 1979, p.5) → Knowledge is objectively knowable (i.e. acquired)
	Anti-positivism	Knowledge "is understood from the point of view of the individuals who are directly involved in the activities which are to be studied" (Burrell & Morgan, 1979, p.5) → Knowledge is subjectively knowable, personally experienced. all observation is value and theory-laden
Human nature	Determinism	→ Human are products of a pre-determined environment, in which laws govern behavior
	Voluntarism	→ Humans are controllers of their environment and have the freedom of choice.
Methodology	Rationalist (nomothetic)	"The research is based on systematic protocol and technique" (Burrell & Morgan, 1979, p.6) → The emphasis is on standardized instruments, and the fundamental methodological issues are the measurement of concepts, identification of themes. The results of the

		research are linked with the ability of tests to be replicated, verified and generalized (Byrman, 1988).
	Ideographic	"One can only understand the world by obtaining first-hand knowledge of the subject under investigation" (Burrell & Morgan, 1979, p.6) → The emphasis is placed upon exploring the detailed background of one's subject.

Table 2: Philosophical assumptions and dimensions

The understanding of the philosophical assumptions enables the researcher to develop a research design that is consistent with the philosophical domain of the research issues and to employ a methodology that supports the appropriate paradigm.

A post-positivist position is adopted for this piece of research. First, post-positivism is founded on a critical realist ontology. Post-positivist researchers argue that reality exists "out there." However, unlike positivists, they believe that this reality can only be imperfectly detected because of individuals' biases in perceiving reality. Post-positivists recognize that all scientific observations are fallible, and all theories are revisable (Kwan & Tsang, 2001). Second, the epistemology within the post-positivist paradigm values objectivity. Nonetheless, unlike positivism, it accepts that it is not possible to maintain distance from the researched, and hence absolute objectivity is unattainable (Crotty, 1998). Post-positivists are assumed as modified dualists and objectivist, where dualism means "a tendency to see divide the world into binary opposites: reason and emotion, culture and nature, body and mind and so on"

(Benton & Craib, 2010, p.180). Researchers adopting this philosophy believe that knowledge is subjective and theory-laden; however, unlike interpretivism, they consider a participant's perception as a "window" to reality and not reality (Healy & Perry, 2000). Essentially, while positivists are "value-free" and interpretivism "value-laden," post-positivists are said to be "value-aware" in a sense that they recognize human interactivity, but they control for it as much as possible to attain objectivity (Gray, 2013).

Accordingly, this philosophical stance has been adopted, as the researcher believes in objectivist ontology, but an interpretive (subjectivist) epistemology, which means that individuals apply their knowledge to phenomena and that this influences how they experience them. In accordance with this, the researcher takes a mostly voluntarist view of human nature, where actions are determined by free will. Nonetheless, in partially reconciling the voluntarist and determinist perspectives of human nature assumption, it is argued that while free will exists, the beliefs, and hence behaviors of individuals are strongly molded by social and environmental structures. In other words, voluntarism is strongly tempered by cultural factors (country, religion, profession, age, etc.) which affect the way people see, judge, and do things. In regard to this study, which seeks to understand engineers ' influence on public policy, multiple interviews allow for different opinions and therefore take into account the subjective element of human interpretation and understanding. With regard to the methodology, since the philosophical stance deviates from the extreme objectivist stance, using deductive reasoning would not capture the entirety of the phenomenon under investigation. Therefore, a more ideographic research methodology that provides a means of evaluating and analyzing qualitative information pertaining to the phenomenon of interest and allows the researcher to construct a perspective will be adopted.

The design adopted in this research will be discussed next.

Research design and methods options

This research employs a grounded theory and a theoretical framework M-O-A to guide the inquiry.

The Motivation-Opportunity-Ability (M-O-A)

The Motivation-Opportunity-Ability (M-O-A) framework will be used as a theoretical framework for the current study. M-O-A has been developed by social psychologists and consumer researchers concerned about identifying factors that impact message elaboration and message-evoked thinking (Hallahan, 2001). Initially proposed by Jaworski and MacInnis (1989), the model suggests that there are three factors influencing brand information processing: motivation, opportunity, and ability. Broadly speaking, motivation refers to the individual's willingness to act, whereas opening reflects the contextual mechanisms enabling actions, and ability captures individuals' capabilities in performing the work (Hallaham, 2000; MacInnis, Moorman, & Jaworski, 1991).

The framework has gained ground in many fields, and has been used to understand a broad array of phenomena, including knowledge sharing behavior among individuals (Gruen, Osmonbekov, & Czaplewski , 2006; Siemsen, Roth, & Balasubramanian, 2008), information processing (Poiesz & Robben, 1996), firm-level decision-making and social capital activation (Adler & Kwon, 2002), marketing performance (Clark, Abela, & Ambler, 2005), social behavior (Binney, Hall, & Oppenheim, 2006), and knowledge management practices (Argote, MCevily, & Reagans, 2003).

By analogy, employing the framework in the context of sociopolitical engineering, specifically to the participation of professional engineers in public policy would mean that achieving higher influence is conditioned by the existence of the three essential antecedent factors: motivation, opportunity, and ability. In this case, motivation would refer to the personal relevance, perceived risks, and goals values. Opportunity, on the other hand, would be associated with the opening given by the government, and ability would be concerned with the competencies of engineers.

Grounded theory method

This section introduces the grounded theory (GT) method, which was selected for conducting this research. The GT method was first coined by Glaser and Strauss (1967) in their seminal work "The Discovery of Grounded Theory" as a reaction against the extreme positivism that had permeated most social research (Suddaby, 2006). Since its introduction, several other versions of the co-originators followed, which developed and debated the GT method (Glaser, 1978; Strauss, 1987; Strauss & Corbin, 1990). GT "is the systematic generation of theory from data acquired by a rigorous research method" (Glaser, 1998, p.3). Along similar lines, Martin and Turner (1986) defined GT as "an inductive, theory discovery methodology that allows the researcher to develop a theoretical account of the general features of a topic while simultaneously grounding the account in empirical observations or data" (p.5) Therefore, a basic tenant of GT is that "all is data," where the researcher needs to continually compare data to generate categories and the relationship among them.

Since its inception, the adoption of the GT has expanded beyond the social sciences research areas and has made inroads into other practical fields and other disciplines (Dey, 1999). This has been enhanced by the usefulness of the GT in a sense that the method enables the identification of general concepts, the development of theoretical explanations that reach beyond the known, and the providing of new insight into a variety of experiences and phenomenon (Corbin & Strauss, 2015).

However, although the GT method has gained resonance, there is an on-going debate about the disciplines to which it can be applied (Charmaz, 2000), and therefore the method was subject to several criticisms, which will be discussed in the following paragraphs of this section.

The philosophical underpinning of grounded theory method

There is considerable debate regarding the underlying philosophical assumptions of the grounded theory method. As stated by Urquhart (2002), "the GT method is paradoxical and unique - a method for analyzing qualitative data which also claims to be a systematic way of generating theory. For this reason alone, there are bound to be debates about whether it is positivist or interpretivist" (p.45). This said, researchers questioned whether it is rooted in positivism or constructivism, and how tightly the GT method is linked to any specific research philosophy. While some suggest that GT is based on a positivist paradigm (Bryant, 2002), others indicate that GT stems from a constructivist model (Goulding, 1998). Fundamentally, the proponents of the interpretive basis believe that the consideration of the GT as a positivist method stems from the fact that the originators of the technique used terminology that has connotations of positivist practices when formulating the GT method (Goulding, 1998).

This on-going debate among scholars represents a dilemma for novice researchers trying to ascertain the philosophical underpinnings of the GT method. This could challenge the credibility of their research, as researchers must be able to articulate their fundamental philosophical assumptions. However, recent advances in the GT method asserted that GT is independent of the underlying epistemology and that it is "paradigmatically neutral" (Glaser, 2001). It can both be used in positivist studies (Urquhart, Lehmann, & Mayersal, 2010), and interpretive and critical reviews (Urquhart, 2001). Midgley (2000) corroborates this view and asserts that there will be a degree of nominalist subjectivity regardless of whether one says that reality is absolute or not because humans are required to sense and understands this reality. Accordingly, a researcher's own ontological and epistemological position will have an impact on their coding and analysis of the data and the way in which they use GT (Madill, Jordan, & Shirley, 2000).

The following figure (figure 8) summarizes the phases of grounded theory:

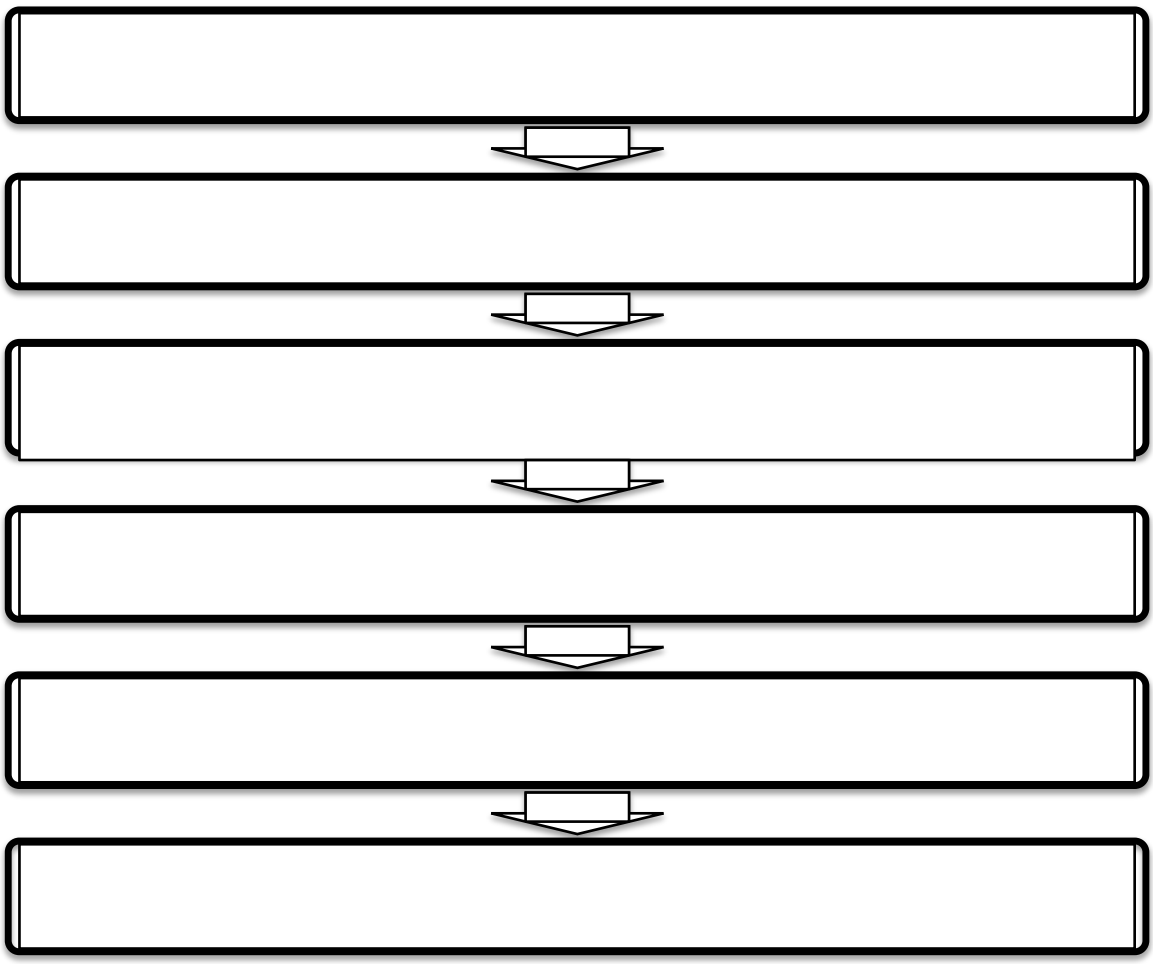

Figure 8: Grounded Theory Phases

Unique features of grounded theory

Although the GT method gained momentum in various disciplines, it is not appropriate for all types of research. Mostly, the GT method is useful for studies "where the process of research might not be one of discovering or establishing truths, but rather concerned with developing understanding and adequate models for specified purposes" (Bryant, 2002, p.35). Specifically, the GT is in considered a viable method in research where the goal is to either "uncover and understand what lies behind any phenomenon about which little is yet known…or gain novel and fresh slants on things about which quite a bit is already known" (Strauss &Corbin, 1990, p.19).

The GT has unique features that distinguish it from other qualitative research. First, the concepts constituting the new theory are derived from data collected during the research process and not chosen before embarking on the data collection process. Therefore, researchers do not need to review all of the literature in the area of investigation beforehand (Corbin &Strauss, 2015). However, this does not mean that the GT requires a researcher to enter the field without any knowledge of prior research (Suddaby, 2006), because such research is likely to produce a random "mass of descriptive material waiting for a theory, or a fire" (Coase, 1984, p.230). Even in their conceptualization of the GT, scholars never intended to encourage research that ignored existing empirical knowledge, and this has been stated in the first formulation of the GT method.

> "Substantive theory is a strategic link in the formulation and generation of grounded formal theory. We believe that although formal theory can be generated directly from data, it is more desirable, and usually necessary, to start the formal theory from a substantive one. The latter not only provides a stimulus to a "good idea" but it also gives an initial direction in developing relevant categories and properties and in choosing possible modes of integration. Indeed, it is difficult to find a grounded formal theory that was not in some way stimulated by substantive theory" (Glaser & Strauss, 1967, p.79)

Essentially, grounded theory research aims at achieving a practical middle ground between a theory-laden view of the world and unfettered empiricism (Suddaby, 2006). A second attribute of the GT method is the fact that the procedures used to enable researchers to investigate topics and related behaviors from various angles thereby developing comprehensive explanations of the phenomenon under study. Third, the processes of data collection and data analysis are interrelated. There is an on-going cycle through which the concepts that are derived from the analysis form the basis for subsequent data collection (Corbin and Strauss, 2015). Fourth, the GT provides a strong foundation for further studies using quantitative measures.

Justification for selecting grounded theory

The GT was selected for this research because of the alignment among the GT approach and the research purpose. Given that there remains ambiguity around the “how” and “what” questions related to the engineers’ influence on public policy, and that this research is looking for a more vibrant exploration process with the objective being theoretical construction, GT was considered an appropriate approach. Moreover, the researcher philosophical perspective was in line with taking a qualitative view of the phenomenon under study. Following the philosophical stance adopted in this research, the GT is particularly relevant because although it contains positivistic elements, the proper use of GT suggests the researcher must be able to understand various perspectives and to be able to construct reality through interpretation of those perceptions, which is in line with the subjectivist epistemological stance of the researcher. However, the study does not seek active intervention, but rather the investigation of the phenomenon in its natural settings (Gummesson, 2000). Consequently, a high level of objectivity is needed to reduce the researcher bias and ensure that the perceptions of actors involved in the phenomenon were efficiently gained.

Research phases and operations of the GT method

As the GT method developed, its originators defined research phases or operations to carry out studies using this approach (Corbin & Strauss, 1990).

These phases can be broadly grouped into two major stages: data collection and data analysis.

Data collection

Sampling

One of the essential aspects in the data collection phase in the GT research process is sampling. Researchers must not randomly select cases but rather should do it incrementally following a theoretical sampling logic. This said, the researchers select an initial case, and on the basis of the data collected and the emerging theory, they select additional cases. As stated by Strauss and Corbin (1990), "unlike the sampling done in quantitative investigations, theoretical sampling cannot be planned before embarking on a grounded theory study. The specific sampling decisions evolve during the research process itself." (p.192).

According to Yin (1989), the theoretical sampling process has three objectives:

- To extend the emergent theory by choosing a case to fill theoretical categories,
- To test the emergent theory by choosing a case to replicate previous cases,
- To extend the emerging theory by choosing a case that is a polar opposite of the previous case. (p.153)

The theoretical sampling process will continue until the point of theoretical saturation, which means that the researcher will stop interviewing engineers when no new relevant data emerges and the relationship between the different categories is established (Strauss & Corbin, 1990). Accordingly, the data collection and analysis are interrelated processes.

Pilot studies

Pilot studies have gained momentum in quantitative research; however, they have been largely misrepresented and underused in qualitative research (Lancaster, Dodd, & Williamson, 2004; Whitheley & Whitheley, 2005). This has emerged as a consequence of researchers' tendency to link pilot studies to more positivist methodological approaches in social sciences research (Sampson, 2004). Based on this assumption, qualitative researchers overlook the benefits of pilot studies, or to a certain extent they are encouraged to do so as pilot studies are rarely well reported in research projects (Kim, 2011).

A pilot study is defined as "the collection of essential research design and development of greater awareness of dynamic events, agents, and circumstances that can positively modify the research process flow and affect decision-making" (Nunes et al., 2010, p. 74). Similarly, Prescott and Soeken (1989) referred to pilot studies as "small scale versions of the planned study, trial runs of planned methods, or miniature versions of the anticipated research in order to guide the development of the research plan" (p.60). Those definitions reflect the importance of a pilot study. Those "familiarization" studies are particularly valuable because "[researchers'] immersion in the field without any pre-exposure can provide them with a feast of fascinating information and observations and can result in not knowing where to start" (Sampson, 2004, p. 389). Pilot studies are also important because they represent "relevance filters" and "procedural scaffolds" (Nunes et al., 2010) that are needed in the current shorter and time-constrained research projects, which leave little scope for deviation.

Accordingly, pilot studies fulfill a range of important functions. At a theoretical level, they provide the researcher the opportunity to gain a more articulated view of the study and a direction in the execution of further research tasks. As stated by Kim (2011), the pilot study is a tool to focus, expand, and narrow down a research topic, and represents also a process to gain a clear conceptualization of the focus of the research. At a methodological level, Sampson (2004) claims that pilot studies provide an enhanced methodological insight because researchers can tailor efficient research instruments and collect preliminary data. At a personal level, pilot studies train the researcher to diverse elements of the research process, as researchers are able to gauge their own abilities and identify potential practical problems that may affect the research process (Van Teijlingen & Hundley, 2005). Essentially, pilot studies reduce the uncertainty inherent to research projects, enable researchers to test the efficacy of their research instruments (Turner, 2005; Kim, 2011; Seidman et al., 1997), and consequently mitigate the risks associated with unfeasible studies. That said, pilot studies should be an integral part of research projects because they provide valuable insights for other researchers.

Nevertheless, pilot studies present some limitations. They are mainly criticized for sometimes misleading the researcher through inaccurate predictions or assumptions (Van Teijlingen & Hundley, 2005). Another challenge in conducting pilot studies is the issue of "contamination." This means "an essential feature of a pilot study is that the data are not used to test a hypothesis or included with data from the actual study when the results are reported" (Peat, Peat, Mellis, Williams, & Xuan, 2002, p.57). Specifically, involving the pilot study participants into the final, a lot of respondents may be negative as those might show declining interest because the research protocol is no longer novel (Van Teijlingen & Hundley, 2005).

Interview type

Gillham (2000) defined an interview as a conversation between two people, in which one person (the interviewer) is asking questions and seeking responses related to a particular topic from the other person (the interviewee). Also, Maykut and Morehouse (1994) described an interview as a form of discourse shaped and organized by the asking and answering of questions, thereby allowing the interviewer and interviewee to talk about the focus of the study, and it also leads to a discussion of thought and perceptions. Interviews can be structured, semi-structured, or unstructured. In this study, the purpose was not to test hypotheses but to understand the experiences and to explore the engineers' influence on public policy. Semi-structured interviews will be conducted with PEs and other engineering or engineering management professionals. Semi-structured interviews can be described as "more or less open-ended questions brought to the interview situation in the form of an interview guide" (Flick, 2014, p.94). The main advantage of semi-structured interviews is that they provide flexibility to dig deeper into a question and ask for explanations when the answer is vague, to get the respondents expand upon their answers and to add additional perspectives as needed (Saunders et al., 2011). However, interviewing presents some disadvantages (Fontana & Frey, 1994). It requires a considerable amount of time and since the researcher (the interviewer) plays a vital role in asking questions, results may be biased (Fontana & Frey, 1994)

Interview design

Following is the interview protocol that will be followed in this study.

Interview protocol

Question category	Objective	Interview question

General questions	Understanding the involvement of PEs in public decision making	● How long have you been working as an Engineer/Professional Engineer (PE)? ● Have you ever been involved in politics as a professional capacity?
Warm-up questions	Perception of PEs	● As an Engineer/Professional Engineer (PE), how do you perceive your right to participate in PE issues? ● As an Engineer/Professional Engineer (PE), how do you perceive your importance to participate in engineering issues?

Motivation-related questions	Determining the factors impacting PEs motivation	● What avenues does an Engineer/Professional Engineer (PE) have, to get more involved in public policy issues? ● Why might an Engineer/Professional Engineer (PE) choose to be involved in public policy issues? ● What are the benefits to an engineer who is participating in public decision-making? o What are they? ● Why might an Engineer/Professional Engineer (PE) choose to not be involved in the political process? ● Why might an Engineer/Professional Engineer (PE) should be attracted the political process? ● How can an Engineer/Professional Engineer (PE) be encouraged to participate in the public decision process?

		• Are there any challenges facing an Engineer/Professional Engineer (PE) in public decision-making, under the American political landscape? What are they?
Ability-related questions	Determining the factors impacting PEs Ability	• How can an Engineer/Professional Engineer (PE) overcome these challenges to ensure that his/her work influences public decision-making? • Why might government look to an Engineer/Professional Engineer (PE) for technical guidance? • Does an Engineer/Professional Engineer (PE) possess qualities enabling them to influence public policy? What are these qualities? • In what capacity can an engineer/ PE participate in public policy decision making? • How can PEs improve the quality of the government? • In the light of engineers' obligations, public safety is of utmost importance. How can the effort of an Engineer/Professional Engineer (PE) in the public decision-making process minimize risks? • How do you, as an Engineer/Professional Engineer (PE), perceive risk in engineering-related issues? • What strengths might you, as an Engineer/Professional Engineer (PE), bring to a public decision-making process?

		• To what extent are engineering programs (schools) preparing future engineers for understanding public policy? • When an engineer participates in public decision-making, are there benefits to society?

Opportunity-related questions	Determining the opportunities provided	• In which stage of the decision-making process are an Engineer/Professional Engineer (PE) involved?
		  ◦ Engineers typically wait for a political decision and then engage in implementation. Do you think PEs involvement should be prior to that?
		  ◦ In which part they would be more effective?

Concluding questions		• Do you have anything to add? • Are there other aspects that you have thought of during our interview that you think might be important for me to know about your influence in Public policy?

Interview process

The interview protocol will be tested in a field test (pilot study). Based on the professionals' feedback, the interview questions will be modified and adjusted. Afterwards, researcher will contact professional engineers and other engineering or engineering management professionals to conduct the interviews for the listed purposes:

- Explanation of the research objectives, the research outputs, as well as confidentiality aspects
- Explanation of the time commitment needed from the participants
- Identify the different aspects affecting the PEs influence on public policy

The interview is held either face-to-face or by telephone, depending on the researcher's resources. To avoid the loss of any information, the participants' responses will be tape-recorded, which will also enable the high reliability of the data collected (Gray, 2013).

Time horizon

Underlying every research project is a time horizon that determines the point at which data is collected. In this regard, two types can be distinguished, cross-sectional or longitudinal. The choice between longitudinal and cross-sectional study is partly influenced by practicality and cost (Sekaran & Bougie, 2003). The present study is cross-sectional as a longitudinal study was impractical given the time constraints of the research. In addition, the fact that the study was not seeking to establish cause-and-effect relationships and examine their influences across various points of time meant that longitudinal research was not essential. As a result, a cross sectional study was selected. This allows a large amount of data to be collected over a single period of time.

Data analysis

Research approach

The nature of the investigated research question determines the research approach used. Bryman et al. (2008) present two fundamental approaches to research – deductive reasoning and inductive reasoning. First, the inductive approach seeks to generate a new theory from the data through the regularities and patterns identified. The researchers generate propositions and build a theoretical framework from their observation of the investigated phenomenon. On the other hand, the main direction of the deductive logic is to generate hypotheses from theories (Saunders et al., 2011) and test them empirically to generate knowledge. Given the emergent status of the topic, a deductive approach would not have been appropriate, and even though, grounded theory is an inductive methodological framework, the approach chosen for this study is not purely inductive. A theoretical framework will be used to guide the inquiry of the research within a constructivist grounded theory study.

Coding

Data analysis for each case involves generating concepts through the process of coding. As defined by the originators of the GT method, coding represents "the operations by which data are broken down, conceptualized, and put back together in new ways. It is the central process by which theories are built from data" (Corbin & Strauss, 1990, p. 67). There are three types of coding as defined by Corbin and Strauss (1990): open coding, axial coding and selective coding.

Coding	Definition and objectives
Open coding	• Produce concepts that seem to fit the data • Events/actions/interactions are compared with others for similarities and differences. • Categories and their properties become the basis for sampling on theoretical grounds
Axial coding	• Relate categories to subcategories • Test relationships against data.
Selective coding	• Integrate the categories that have been developed to form the initial theoretical framework

Table 3: Coding Process

Open coding

In open coding, the researcher aims at generating categories and their properties, which in turn stimulates theoretical sensitivity through generative and comparative questions that further guide the research. Moreover, comparing the groups and their properties enables researchers to break through subjectivity and bias.

Axial coding

Axial coding is the second procedure of the coding process where relationships between categories and subcategories are modeled and tested against the data.

Selective coding

This represents the process by which all emerged categories are unified around a core category that describes the central phenomenon of the study (Corbin & Strauss, 1990). During the coding process, hypotheses about relationships among categories should be developed and verified as much as possible. Although the founders of the GT method adopted the term hypotheses to refer to the GT findings, the term “hypothesis” does not denote the same meaning as in quantitative studies, and therefore other authors used the term propositions instead. Those propositions are in fact a “set of conceptual hypotheses… probability statements about the relationship between concepts” (Glaser, 1998, p.3). In GT, interpretations of hypotheses are constantly checked by the constant comparative method and theoretical sampling (Glaser, 1998). The fact that the direction of new data collection is determined by emerging conceptual categories, and not by a priori hypothesis violates the ideal of hypothesis testing (Suddaby, 2006). This said, “The hypotheses should work and in so far they do not, constant coding and analyzing of the data modify them until they do” (Glaser, 1998, p.3).

Data management and analysis

The Use of qualitative software: NVIVO software

Data management represents the process by which all emerged categories are unified around a core category that describes the central phenomenon of the study (Corbin & Strauss, 1990). The use of the NVivo software supported this research process. It significantly helped the researcher to organize and arrange the data**.** For instance, once the coding process is completed, the researcher may view all the statements assigned to the same code in one screen, which facilitates searching across data as well as doing comparisons. Furthermore, the researcher adopted a specific formatting when transcribing the interviews to ease importing the transcripts into NVivo. For example, “Heading 1” was assigned to all questions, and “Heading 5” was assigned to all answers. Hence, it is easier for the researcher to search within the content.

Analysis using Q method

The integration of Q method

To embellish the primarily qualitative data, the researcher integrates quantitative method analysis through the use of Q method (Figure 9).

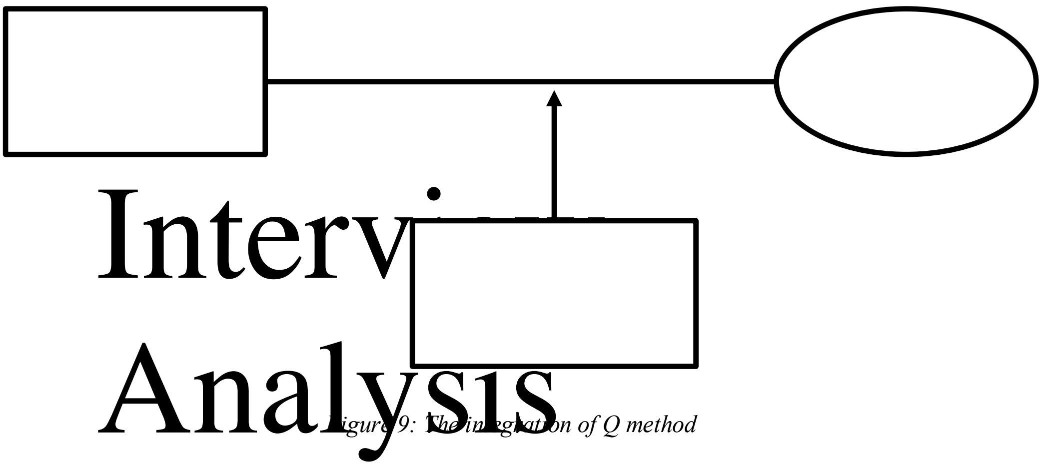

Figure 9: The integration of Q method

Steckler et al. (1992) suggested four approaches describing the fusion of qualitative and quantitative method in a study**.** The first model consists of the adoption of qualitative data collection to develop a quantitative instrument. The second approach involves the use of qualitative results to interpret findings within a quantitative study. The third approach consists of the use of both qualitative and quantitative methods equally

Finally, in the fourth model, which was adopted in this research, is a quantitative analysis used to help further interpret qualitative findings.

Q method: definition

Q methodology was first introduced by the British physicist/psychologist William Stephenson in 1935 (Brown, 1993), and is used by researchers to study the subjectivity of various topics (Brown, 1996), it employs both quantitative and qualitative techniques, resulting in it being called "qualiquantological" (Stenner & Stainton Rogers, 2004). This methodology fits into the qualitative approach since subjectivity is associated with qualitative framework (Stenner & Stainton-Rogers, 2004). However, Q method is different than a typical qualitative research because it uses statistical analysis (Stephenson, 1953) to preserve the association between themes within the data while reducing the impact of the researcher's frame of reference (Stainton-Rogers, 1995).).

In this study, Q method was conducted to determine the perspectives of engineers on the important factors of their influence on public policy. This was accomplished using the two main characteristics of this method, namely, Q sorting and factor analysis (Watts &Stenner, 2005).

Q method analysis steps

The following graph summarizes the steps of the Q method:

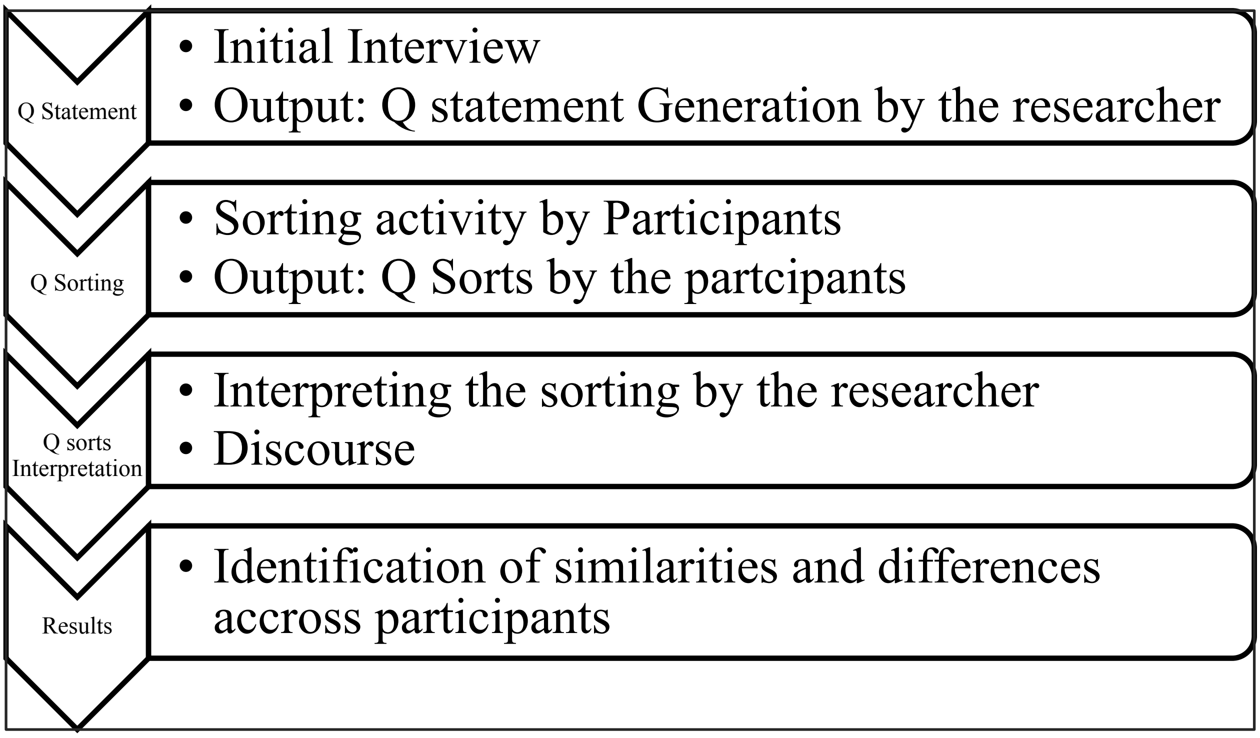

Figure 10:Q methodology Steps

The first step of a Q method is to collect data from participants via interviews, which was discussed in the previous section. From the ideas and opinions provided by the participants, a set of statements was developed. The second step was the placement of the statement in a grid distribution to measure subjectivity (Brown, 1996). Each participant was required to sort the items (Brown, 1996) according to his own point of view. The sorting phase is what determines the factors during the analysis (Brown, 1998). Prior to starting the rank order, the research has the option to either give participants the choice or ask them to follow certain instructions (Denzine, 1998). For instance, the research may choose a specific number of pills, therefore limited number of statements can be placed under one pill.

The research may also give participants instruction on how to start the sorting. For instance, dividing the number of statements into three groups (agree, neutral, disagree) and then starting the placement into the distribution grid. They use a rating scale that depends on the number of statements used in the study using agree to disagree based on a rating scale from +5 to -5 or +4 to -4. Following is an example of Q sort diagram.

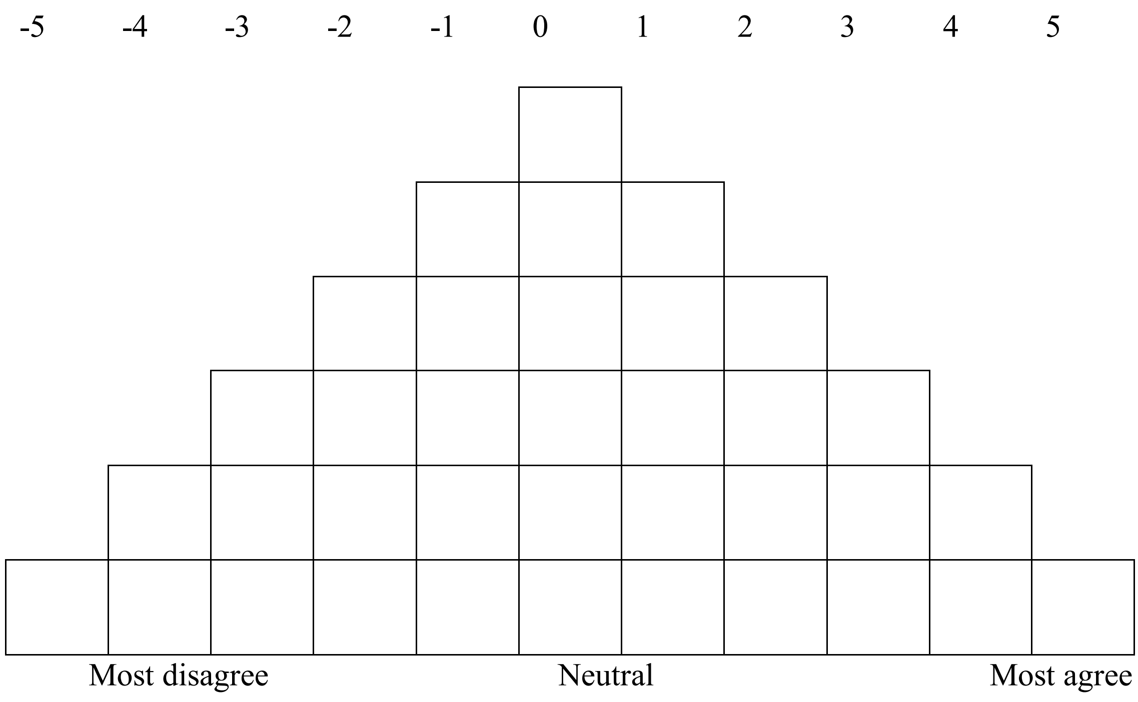

Figure 11: Q sorting diagram/ Grid distribution

Generally, the number of statements should be between 30 and 100 but is typically between 40 and 80 (Stainton-Rogers, 1995) and due to the limited data, the researcher was able to collect, 36 statements will be used in this study. Once the Q sorting is accomplished, results are analyzed using Q factor analysis.

The goal of Q methodology in this study was to further emphasize the results of the coding process based on the view point of engineers. Although, reliability was not a major concern for this phase of the study, "factors determined in Q are grounded in concrete behavior and are typically reliable and replicable" (Ramlo, McConnell, Duan, & Moore, 2008, p. 220). Validity is also not a major concern for this phase of the study. The sorting of the items is based on the participants' interpretations. Thus, when using Q validity is not a concern (Ramlo et al, 2008; Ramlo, 2011). According to Ramlo (2011) because the sorting process involves interpretation of the items by the sorts and each are judged relative to the others based upon this interpretation, validity is not a consideration within Q methodology studies. In other words, no external criterion for a person's point of view exists and, therefore, the issue of validity of Q sorts does not apply. Nonetheless, as was mentioned above, short interviews were conducted following the Q sorts—when possible—to reveal how participants interpreted the statements

Methodological limitations for grounded theory

Generalizability

A primordial aspect in qualitative studies in general and in GT studies in particular is the generalizability of the emerging GT. Although generalization is not the purpose of qualitative research (Corbin & Strauss, 2015), this objective is achieved through the process of abstraction carried out over the course of the data collection and analysis (Corbin & Strauss, 1990). The researcher takes into consideration broader structural conditions, however microscopic the research, which specifies the conditions under which the phenomenon has been discovered (Corbin & Strauss, 2015). Therefore, the core concepts that emerge from one study are broad enough to have application beyond the case from which they were derived, though the specifics might differ. Specifically,

> The more abstract the concepts, and the more variation uncovered in the original study, the more likely it is that the propositions apply to a broad range of situations (…) A GT is generalizable insofar as it specifies conditions that are linked through action/interaction with definite consequences. The more systematic and widespread the theoretical sampling, the more completely the conditions and variations will be discovered, permitting greater generalizability, precision, and predictive capacity (Corbin &Strauss, 1990, p.15).

Criticisms of grounded theory methods and the goodness of research

Although the GT method has been laudable for the insights it brought to various domains, it has been subject to several criticisms alike. One criticism was related to the philosophical divergence between the originators of the GT in developing their original concepts (Goulding, 1998; Dey, 1999). Moreover, the issue of hypothesis verification has been subject of on-going debate. While Glaser posits that the aim of GT is to generate hypothesis not to test them, Strauss and Corbin (1990) assert that verification is an integral part of the GT process itself. Furthermore, scholars criticized the GT method for its methodological deviations pertaining to the application of quantitative canons of rigor to GT (Wilson & Hutchinson, 1996). Those canons, although useful, must be redefined to fit the realities of GT research and the complexities of social phenomena (Corbin &Strauss, 1990). Specifically, researchers "do not follow the traditional quantitative canons of verification. They do, however, check the development of ideas with further specific observations, make systematic comparisons and often take the research beyond the initial confines of one topic or setting" (Goulding, 1998, p.55). Another shortcoming of the GT is referred to as premature closure, which means that the researcher fails to develop abstract concepts that are the essence of the emerging theory (Wilson & Hutchinson, 1996; Dey, 1996).

Furthermore, scholars argue that the fact the researchers using grounded theory bring their own views and biases into the research which may affect its credibility (Charmaz, 2006; Mills, Bonner, & Francis, 2006). This explains why constructive grounded – using grounded theory as well as a theoretical model - to guide the researchers' inquiry. Constructivist grounded theorists "do not attempt to be objective in their data collection or analysis, but instead seek to clarify and problematize their assumptions and make those assumptions clear to others" (Edwards & Jones, 2009, p. 212).

This is not to say that the GT is not worth retaining or using in the investigation of phenomenon, but those elements should be handled properly and taken into account during the research design. The researcher should have a theoretical sensitivity with regards to existing literature and theory. Furthermore, the research design should emphasize the importance of constant comparison for continued review of assumptions and develop abstract conceptualizations throughout the entire research process to ensure theoretical generalizability.

For these reasons, a constructivist GT approach and a theoretical framework are appropriate for exploring the research question.

Summary of the methodological considerations of the study

This chapter has outlined the argument for the philosophical and methodological approach and strategy based on the research questions developed in this thesis. The chapter made a case for the philosophy of post-positivism and explained the chosen grounded theory method and responded to criticisms of this strategy.

CHAPTER 4
DATA ANALYSIS AND RESEARCH FINDINGS

In this chapter, the researcher provides an analysis of the data obtained from the interviews. It presents the research's findings embodied in three phases. The first phase focuses on the field test, the second phase evaluates and analyze the in-depth interviews to develop a theory, and the third phase focuses on the analysis Q set statements elicited from the interviews and the Q sorting to evaluate the perception of the participants.

First Phase: Pilot Studies

Initial research objectives

Prior to illustrating how the pilot study contributed to the main research, it would be useful to briefly state the objectives of the present doctoral thesis. There is a limited involvement of engineers in public policy. Therefore, one fundamental question is how engineer can influence decision-making and public policy, to bridge the gap between the two disciplines.

Pilot study objectives

The objectives of the pilot study were threefold. First, the researcher aimed to assess whether the theoretical framing of the study could be confirmed in the field. Second, it aimed at testing the interview protocol and identifying any difficulties in communicating the questions to engineers. Finally, the pilot work sought to discover any other practical issues and difficulties. The purpose is to confirm the appropriateness of the questions rather than providing data.

Pilot study findings

The engineers' feedback enabled the researcher to review the questions and modify them by adjusting some words, avoiding some repetitions, and refining the interview questions, making them clearer to the respondents. For instance, the question “Have you ever been involved in political process?” was not very clear. Therefore, the researcher redirected the question towards public decision-making process. Moreover, some questions did not allow the researcher to capture the nuances sought from the interview. For example, when engineers were asked about the risk analysis, it is either they answered the question in a very broad manner, or their answers were very brief. The table below illustrates how the interview questions were altered.

Interview questions before modifications	**Interview questions after modification**
How can an Engineer/Professional Engineer (PE) be encouraged to participate in politics?	How can an Engineer/Professional Engineer (PE) be encouraged to participate in the public decision process?
What approaches does an Engineer/Professional Engineer (PE) have, to get more involved in public policy issues?	What avenues does an Engineer/Professional Engineer (PE) have, to get more involved in public policy issues?

This goal was accomplished; the pilot study proved to be beneficial for the development and modification of the research instrument.

Second Phase: Interviews

As explained in the previous chapter, the researcher selected in-depth interviews as the method of data collection. Within this approach, participants share and explain their view related to the influence of professional engineers on public policy. A one-to-one semi structured interview was chosen, with predetermined questions that had a specific focus. This type of interviews enables the research to draw out themes in a relatively grounded manner and gives the researcher the opportunity to inquire more details and get clarifications from the interviewee if follow up questions are required (Whyte, 1982; Rubin & Rubin, 2005). The interviews lasted from half an hour to one hour; were recorded and transcribed verbatim in order to preserve the entirety of statements, and allow high reliability of the data (Gray, 2013).

To answer the first research question NVivo software was used. Once the interviews were transcribed, the researcher started the analysis.

Participants' profiles

Theoretical sampling was used to select participants to get the maximum information that can contribute to theory generation (Jones & Alony, 2011). The demographics of the respondents, including their gender, education level, and years of career experience, are provided in the following table.

Engineers	Academic degree in Engineering	years of experience	Gender
1	PhD	2 in academia	F
2	PhD	8 in academia	M
3	PhD	20 in industry	M
4	PhD	7 in industry	M
5	Master's	5 in industry	F
6	Master's	7 in industry	M
7	Master's	2 in industry	M
8	Bachelors	15 in industry	F
9	Bachelors	8 in industry	M

10	Bachelors	3 in industry	M
11	Bachelors	10 in industry	M
12	Bachelors	1 in industry	M
13	Bachelors	5 in industry	M

Table 4: Participants Demographics Coding process definition

Coding is a very important process in grounded theory. It aims at reducing and categorizing the field data. By definition, coding is “tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study” (Miles & Hubrman, 1994, p.54). The following figure (Figure 12) explains the data collection and analysis process used.

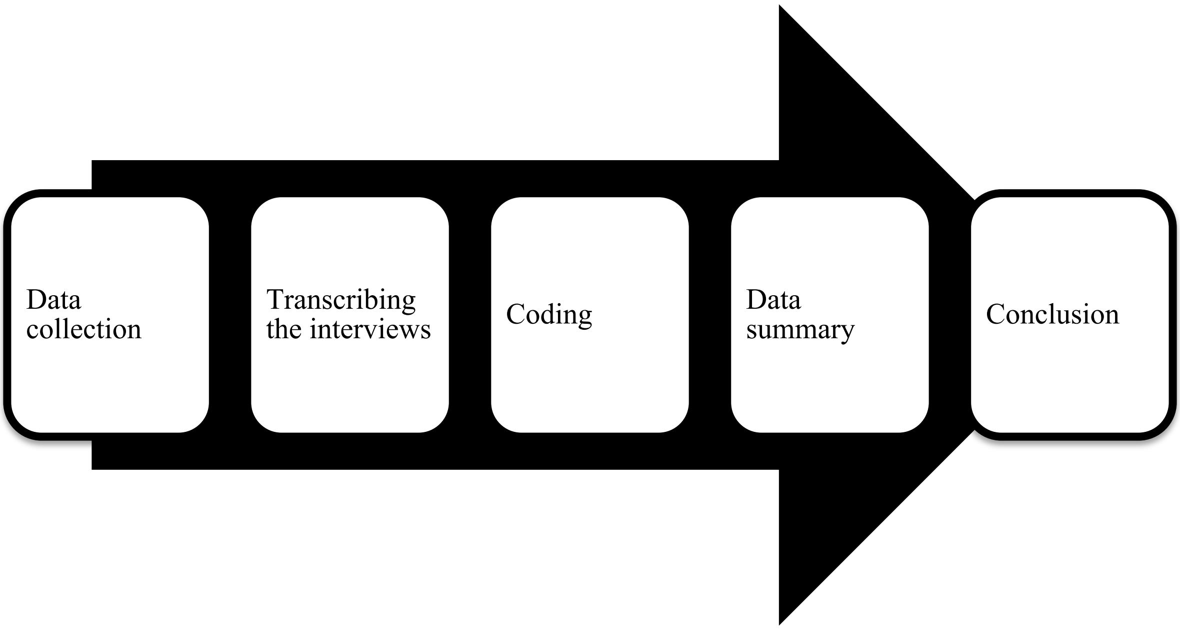

Figure 12: Data collection and analysis

The coding process was enhanced through the use of computer-based tool NVivo.

NVivo procedure steps

Dainty, Bagilhole, and Neal (2000) stated that this computer-based tool facilitates the data management as well as the coding process. Before using the software, the researcher received training offered by Old Dominion University, which provided her a detailed tutorial on the techniques of the software. Bazeley and Jackson (2013) discussed the procedures to be followed (Figure 10).

Figure 13: Nvivo procedures.

The first step to start a project in NVivo is its creation. In this study, the researcher created a project and named it "Socio Political Engineering." The second step is the preparation of the documents before importing them to NVivo. The third step is to start the analysis by creating nodes, categories, and themes from the data, which will be discussed in the next section.

Coding phases: open, axial, and selective

By using the three phases of coding, characterized by a cyclical connection (LaRossa, 2005, p. 840), the researcher started processing the data using both constant comparison and theoretical saturation.

The following section will explain the model and answer the first research question. The researcher imported the transcribed interviews into NVivo (figure is an example of document in NVivo) and started the coding process.

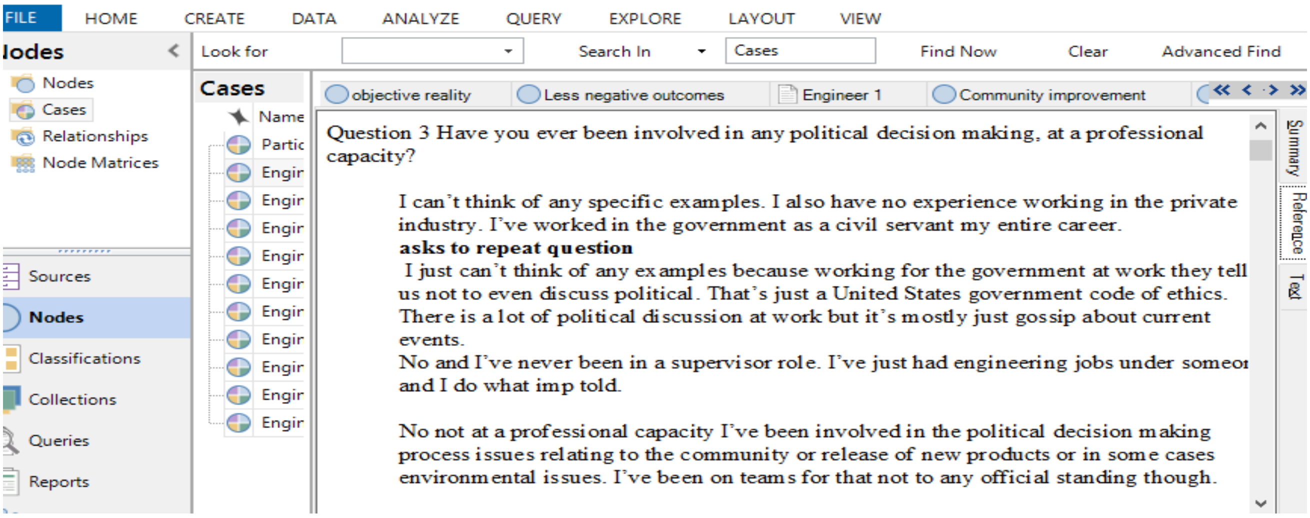

Figure 14: Example of NVIVO

The researcher read word by word the transcripts various times and assigned key words to each statement.

Open coding

During the open coding, a long list of themes emerged from the interviews (graph) which was highlighted by Merriam (2009): "At the beginning of an inquiry, this list is likely to be fairly long because you do not yet know what will surface across the rest of the data. You also will not yet know which groupings might be subsumed under others" (p. 180).

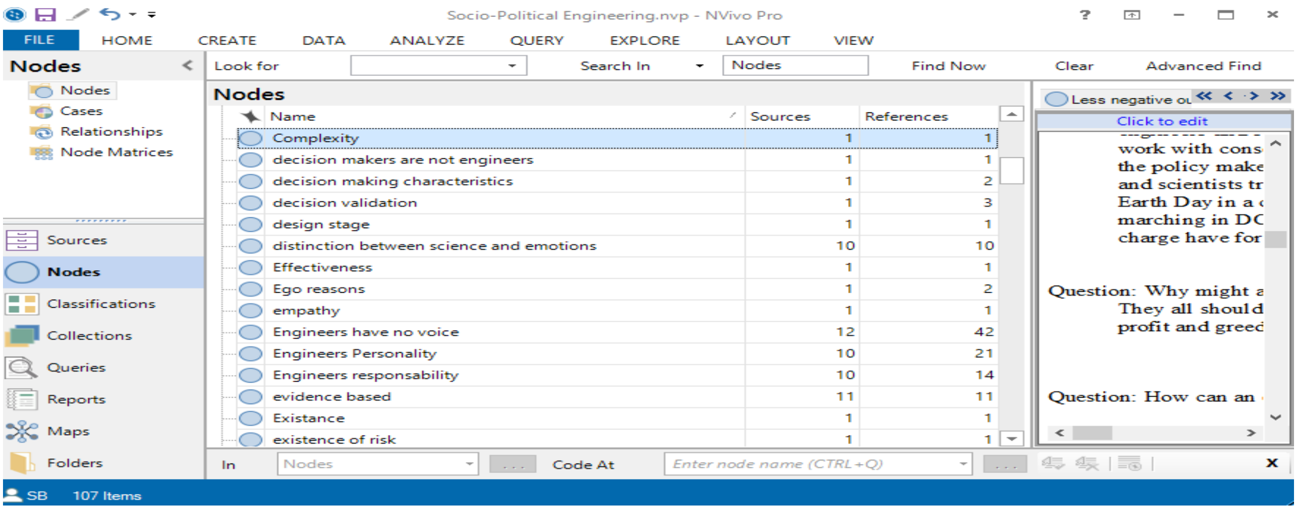

Figure 15: Open Coding Example

During this phase, the researcher used a constant comparison technique in order to compare the data and gauge similarity and differences. This technique helped the researcher to start the conceptualization, which is finalized within the axial coding step.

Axial coding

During the axial coding (Glaser 1967) or Focused coding (Charmaz,2006), the researcher used the 5 key question suggested by Charmaz in order to do the analysis. The questions are:

- What process is at issue here?
- What are the conditions behind the development of the process?
- Within this process, what are the participant's thoughts and feelings?
- When, why, and how does the process change?
- What is the output of the process?

Taking these questions into consideration, key phrases were conceptualized and were grouped based on the similarities to create the main categories. The researcher uses different levels of thinking including reflective, creative, and critical (Ruggiero, 1996) to develop themes based on the interaction and discussions with the participants. During this process, the researcher used memos to organize the patterns between the codes (Glaser &Strauss, 1967). This process of organizing the researchers' thinking was encouraged by Charmaz (2006), stating that using memos aid the researcher to manage the plethora of ideas while the research is progressing**.** The purpose of using memo-writing is fourfold:

- Raise the data to a conceptual level
- Encourage the sorting and reworking of ideas
- Serve as the source for writing up the theory
- Provide organization

In this study, the researcher used memos to organize the similarities and dissimilarities within the data and manage the emerging variables.

Selective coding

During the last stage of coding, the researcher excavates the principle variables that tie the data together into one theory. Within this final level of coding, the researcher assembled the different categories under specific concept. The following figure is an example of the "ability' concept and its categories.

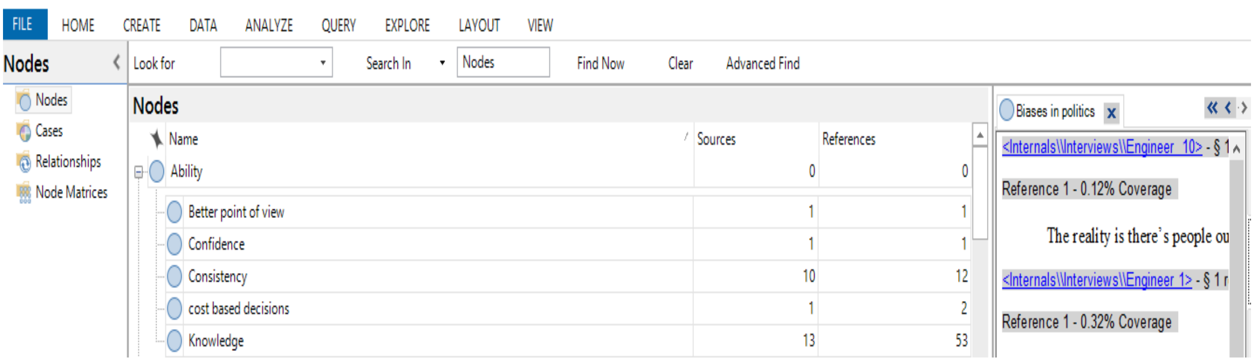

Figure 16 Selective Coding

These concepts were put into a coherent composition explaining the theory developed, which should be understandable and "judged by the range, density, linkages between and systematic relatedness of its theoretical concepts, as well as by the theory's specificity and generality (Denzin, 2004 p. 329).The results of this phase area conveyed in Chapter 6**.**

Coding Limitations

One of the major limitations of NVivo software is that it does not produce any outcomes; it just assists the researcher to organize the data in order to find relationship between the data and formulate findings. Consequently, the research should have a strong ability to code qualitative data.

Coding Process Summary

The following table summarizes the process followed by the researcher.

	open coding	**axial coding**	**selective coding**
codes	150 codes	11 codes	11 codes 3 main themes
activities	Constant comparative analysis	themes generation	Relationship between codes

Table 5: Coding Process Results

Three main themes and various categories were generated (Table 6).

Themes	Categories
Motivation	● Self-Satisfaction ● Leadership ● Power ● Education ● Responsibility
Ability	● Knowledge/experience ○ risk management ○ technical skills ● Soft Skills ○ personal attributes ○ communication skills
Opportunity	● Participation in specific policy process stage ● Learning opportunity

Table 6: Themes development

After generating the different themes and the memos, the research revised the selective code with respect to the related literature in order to explain the theory which will be discussed in Chapter 5.

Third phase: Q method analysis

In this study, Q method will be used to study the dominant perception of engineer participants regarding their influence on public policy. The background of this method was explained in Chapter 3 of this dissertation (refer to Chapter 3). The following figure summarizes the Q method process.

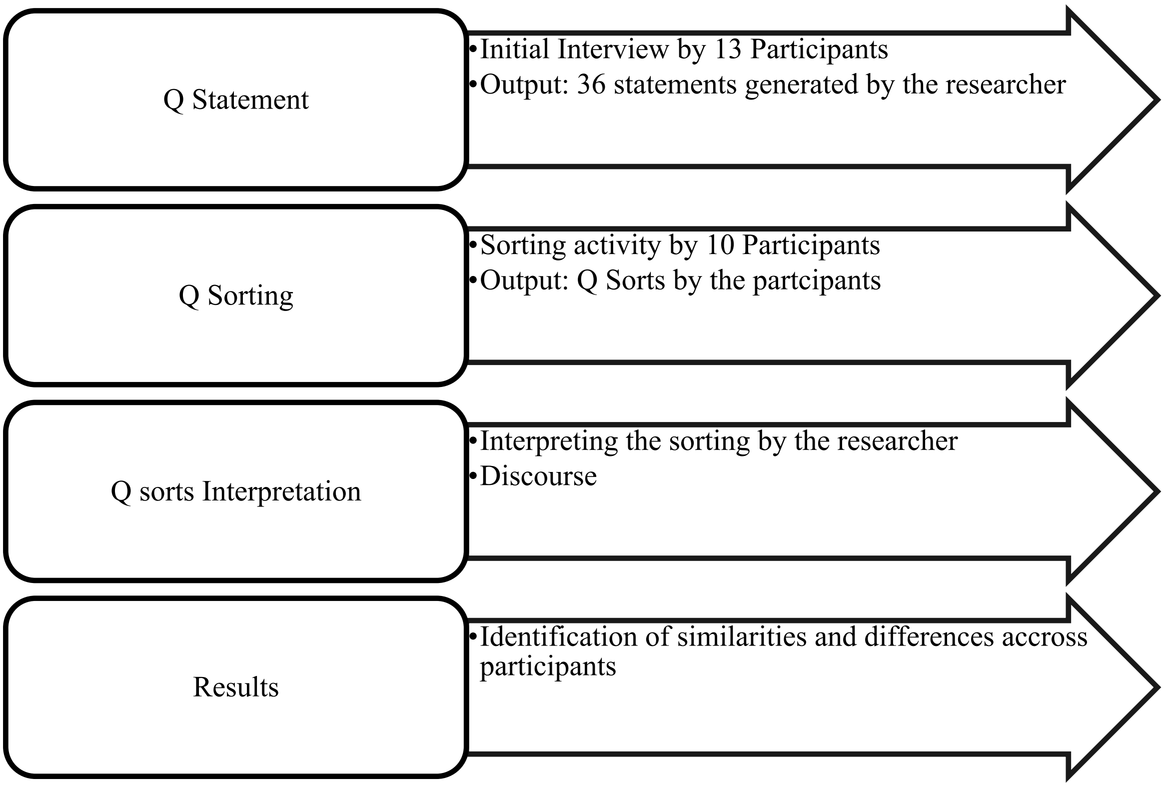

Figure 17: Q method process of the current study

Q Statement generation

Based on the interviews conducted in phase 2 of this study, the researcher developed a set of statements structured by applying Fisher's (1960) methods of experimental design, which led to a conceptualized set of statements including different aspects. A list the statements were developed based on the interviews, which means they are grounded on concrete data, and then similar statements were clustered together based on the M-O-A framework to form a Q sample (List of the statement is provided Appendix 5). Each statement was assigned a number that participants used during the sorting process.

Sorting procedure

The purpose of a Q study as stated in the previous chapter (Chapter3) is to clarify the statements that are favored by the participants. Even though the sample size is not important in Q method, Stainton and Rogers (1995) specified that a study is more effective when the group of participants ranges between 40 and 60. However, Watts and Stenner (2005) stated that large numbers might be problematic, justifying the use of fewer number participants. In this research, there were a limited number of participants. Ten engineers were given the necessary instructions on how a Q method should be carried out, and each one completed the sorting on an excel sheet, which was then copied by the research into the Q software to run it. It was also explained that in this research, participants would use a structured Q sort meaning they followed the instructions given by the researcher, each researcher has to rank order the statement using agree to disagree based on a rating scale from +5 to -5. Following is an example of Q sort diagram completed by engineer 2.

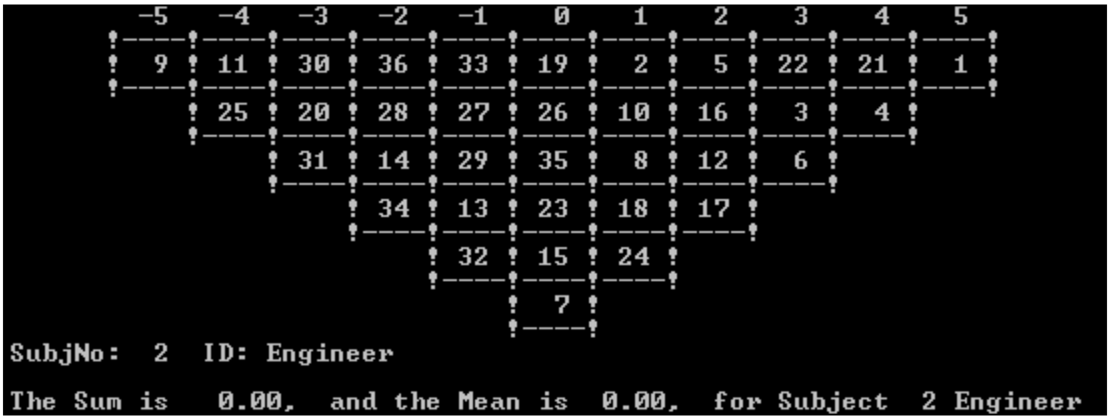

Figure 18: Q sort example

Statement 1 represents the most agreeable item, ranked at +5, whereas the most disagreeable is statement 9 ranked at -5 meaning that, in this example:

Statement1: My participation in public decision making is crucial because I have all the technical skills needed to make the right decisions. (Agree)

Statement9: the political process or decision-making process is frustrating and requires time (disagree).

As is apparent, engineer 2 believes that engineers can make effective decisions and this perceived ability is a motivational factor. He also disagrees that the decision-making process is frustrating. He explained his choice further after the Q sorting was completed by saying, “Something is frustrating when people do not understand it. I disagree that public decision-making is a frustration, we engineers are not familiar with it”

The data for all the engineers participating in this study were combined into the following matrix.

Statement/Engineer	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
1	3	5	4	4	5	4	4	5	5	4
2	-5	1	-5	-3	-4	-4	-3	-3	-5	-4
3	4	3	4	-1	3	3	3	4	3	0
4	3	4	3	1	1	1	2	2	4	4
5	2	2	2	0	2	1	0	0	2	0
6	3	3	2	3	4	4	3	3	3	3
7	0	0	1	-1	0	0	0	0	0	-1
8	2	1	1	1	1	1	0	1	1	3
9	0	-5	0	4	2	3	2	2	1	3
10	1	1	1	0	1	1	0	1	1	1
11	-1	-4	-4	-4	-3	-2	-5	-4	-1	-4
12	2	2	2	3	3	3	4	3	2	2
13	-2	-1	-1	-1	0	0	0	-1	-2	-1
14	-2	-2	-1	0	-2	-1	-1	-1	-2	0
15	1	0	1	-2	0	0	0	1	0	-2

16	1	2	5	0	2	2	2	0	1	1
17	1	2	3	2	1	2	3	-1	1	1
18	2	1	0	2	2	2	2	2	4	1
19	1	0	0	1	0	1	0	3	0	1
20	-3	-3	-4	-5	-5	-4	-4	-3	-3	-5
21	4	4	3	1	3	-1	0	1	-1	-1
22	5	3	2	5	4	5	5	4	0	5
23	0	0	0	0	-1	-1	-1	0	0	0
24	0	1	0	2	1	2	1	2	2	2
25	-4	-4	-3	-4	-4	-5	-4	-5	-4	-3
26	0	0	0	-2	-1	0	-2	-2	-1	-1
27	-1	-1	-2	-1	0	0	0	0	0	0
28	-3	-2	-2	-1	-3	-3	-3	-2	-2	-2
29	0	-1	-1	3	-1	0	0	0	2	2
30	-2	-3	-3	-3	-3	-2	-1	-2	-1	-3
31	-1	-3	-2	2	-2	-3	-2	-2	-1	2
32	-3	-1	-1	0	-1	-1	-1	-1	-4	0
33	-4	-1	-2	-3	0	-1	-1	-4	-3	-2
34	-2	-2	-1	-2	-2	-3	-3	-3	-3	-3
35	-1	0	1	-2	-1	-2	-2	-1	-1	-2
36	-1	-2	-3	1	-2	-2	-2	1	-2	-1

Figure 19: Sorting Matrix

Once the researcher entered the data received from all participants, a correlation option was selected within the software. The correlation results are as follows:

Correlation Matrix Between Sorts

SORTS	1	2	3	4	5	6	7	8	9	10
1 Engineer	100	74	82	66	85	80	80	83	87	70
2 Engineer	74	100	79	46	76	64	71	67	67	53
3 Engineer	82	79	100	56	85	76	80	70	76	64
4 Engineer	66	46	56	100	74	76	77	78	65	91
5 engineer	85	76	85	74	100	92	91	83	80	77
6 Engineer	80	64	76	76	92	100	94	85	76	81
7 Engineer	80	71	80	77	91	94	100	85	75	81
8 Engineer	83	67	70	78	83	85	85	100	78	78
9 Engineer	87	67	76	65	80	76	75	78	100	69
10 Engineer	70	53	64	91	77	81	81	78	69	100

Figure 20: Correlation Matrix

According to the matrix, engineer 10 shows a moderate correlation with 2 and 3 (with .53 and .64, respectively), engineer 4 is also relatively correlated with 1, 2, 3, and 9 (.66, .46, .56, and .65, respectively). Others show a high correlation. However, in Q method it is important to note that the researcher is not trying to find how participants correlate but to discuss the overall perception (Sell & Brown, 1984). The step that follows the correlation is the factor analysis.

Factor analysis

Using Q software, the analysis was performed, and the researcher was able to run the factor analysis. This analysis aims to demonstrate the similarities among engineers who participated in the sorting session, revealing a pattern of statements that express their perspective on the topic.

Following is the extraction of Unrotated Factor Loading:

Unrotated Factor Matrix

SORTS	Factors 1	2	3	4	5	6	7	8
1 Engineer	0.9122	-0.1766	0.2503	-0.0067	0.0010	0.1725	0.1840	-0.0825
2 Engineer	0.7816	-0.4694	-0.1862	0.3156	0.1538	-0.0925	0.0300	-0.0234
3 Engineer	0.8667	-0.3350	-0.1006	-0.0169	-0.2849	0.1594	-0.1300	0.0390
4 Engineer	0.8212	0.4994	-0.0023	0.1984	-0.0363	0.0237	0.0455	0.1559
5 engineer	0.9536	-0.0716	-0.1062	-0.1252	-0.0309	-0.0501	0.1176	0.1472
6 Engineer	0.9331	0.1035	-0.1166	-0.2681	0.0411	-0.0728	0.0520	-0.0763
7 Engineer	0.9448	0.0540	-0.2019	-0.1400	0.0363	-0.0644	-0.0566	-0.0380
8 Engineer	0.9119	0.0994	0.1001	-0.0350	0.3180	0.1468	-0.1437	0.0269
9 Engineer	0.8724	-0.1302	0.4046	-0.0064	-0.0719	-0.2137	-0.0815	0.0237
10 Engineer	0.8622	0.4081	-0.0432	0.1745	-0.1332	-0.0156	-0.0243	-0.1701
Eigenvalues	7.8774	0.8253	0.3487	0.2782	0.2342	0.1437	0.1014	0.0923
% expl.Var.	79	8	3	3	2	1	1	1

Figure 21: Unrotated Factor Matrix

Factor analysis helps the researcher reveal the similarities between the sorting of the statements. It is a holistic approach considering the entire sorting of statements. Respondents usually load significantly on the same factor if they share the same viewpoint, placing their statements in similar positions in the grid. Thus, the factor analysis process reveals the number of respondents expressing subjective views that are common to each factor.

In the above table, it is shown that all Q sorts load high on factor 1 and lower on the other seven factors, which makes factor 1 the "prominent factor." The statements were selected at a 99% confidence level using the following formula:

$\pm$ 2.58 x 1/$\sqrt{36}$ (the number of statements in the Q set) = $\pm$ 0.43.

Sorts which scored 0.43 or more for a factor were selected. Referring to the same table, the loadings of all engineers (in factor 1) exceeds .43, which proves a mutual perspective of the participants.

Furthermore, in order to decide which factor will be rotated, the research first followed the eigenvalue rule proposed by Kaiser (1960). This rule stated that factors with eigenvalues greater than one are the ones to be rotated. The rationale behind this is that, if the eigenvalue is less than one, then loading of the components within the factor has negative reliability (Cliff, 1988). This eigenvalue can also be calculated using the following formula:

Eigenvalue= (the variance x the number of participants) / 100.

It is used in R methodology to decide on the variance extracted, while in Q method, even though this rule is taken into consideration, not all factors below one are discarded. Sometimes, depending on the dataset, the eigenvalue is not always taken into account to prove the significance of a factor (Herrington & Coogan, 2011). In the following research, the Eigen value of factor 1 is 7.87, which is very significant. Therefore, factor 1 represents a mutual participant's viewpoint, while all the other factors' eigenvalues are below 1. In this case, since the instrument is unidimensional, the process of manipulating the reference axes defining rotation (Child, 1990) won't follow because no rotation is possible (Osborne, 2015). However, the researcher forced and selected factors based on theoretical considerations. Three elements were chosen, disregarding the Eigenvalues, and then rotation was performed (results are provided in Appendix 7).

Summary of chapter 4

This chapter provides a detailed account of the findings from the empirical data collection phases. Accordingly, this chapter is structured into two parts; the first part discusses results from the pilot study, the second part focuses on the analysis of the in-depth interviews, and the third phase focuses on Q sorting. Grounded theory codes, memos, and demonstrations of ideas provide an insight into how the final grounded theory categories were developed to answer the first and second research questions. The methodology for this study, which was discussed and explained in the previous chapter, guided the data collection as illustrated in this chapter (Chapter 4). The resultant theory does not need separate justification and testing because it came from live data (Allan, 2003). However, the researcher chose to integrate a Q analysis to investigate the perception of engineers on the topic. Q analysis is based on sorting a set of statements derived from the interviewees' answers, followed by factor analysis to examine the perceptions of engineers concerning this topic. The researcher was concerned with the overall pattern of perceptions that emerged (Brown, 2004).

The focus of this chapter was to present and discuss the results of the different phases of data collection, and a discussion of those findings is provided in Chapter 5.

CHAPTER 5

DISCUSSION AND THEORY DEVELOPMENT

This chapter reflects on the main findings of the research by linking the findings to the existing literature to ascertain whether or not it supports the existing data. Then, the chapter concludes with an explanation of the developed theory.

Analysis of the themes

Motivation factors

Several theories attempt to explain the motivation and the factors affecting it. The most popular explanations were suggested by Maslow and Lewis (1987), Frederick Herzberg (1968), and Clayton Alderfer (1977) within different contexts excluding the engineering and public policy field. Thus, this study is the first to explore in depth the factors impacting engineers' motivations to influence public decision-making (Figure 12 illustrates the findings). The critical drivers identified are personal satisfaction, education, leadership, and power.

Personal satisfaction

Personal satisfaction emerged as one of the factors motivating engineers to influence public decision-making. Ego reasons driving engineers' motivation was clearly described by engineer 1 who reported, "I would participate just to think of one's self as being important, to make my voice heard." This can be explained by ego reasons driving his motivation. Furthermore, engineer 2 mentioned, "I believe that I have valuable skills that can make governmental organization make a better decision." This claim clarifies that this participant has strong self-esteem and confidence in his ability to influence a governmental decision. This is consistent with research in psychology. Researchers found that self-esteem is interrelated with motivation (Maslow & Lewis, 1987), where an individual with high self-esteem tend to be more motivated to do more whether, in his personal or professional life, and it is a growing need that impacts his motivation (Alderfer, 1977). Along similar lines, Eccles and Wigfield (2002) stated that confidence in someone's ability increases his motivation to complete a task. Thus, this research proposes the following:

Proposition 1: Self-satisfaction is a factor that impacts engineer's motivation

Education: engineering and public policy

Data indicated that most of the engineers are not involved in public decision-making due to their lack of knowledge related to this discipline. Nine participants out of 13 mentioned that introducing engineering students to public policy concepts is important. One noted remark came from engineer 10 who stated, "I reflect for myself, 'Am I qualified enough to voice my concern?' Lack of education when it comes to policymaking. I have to ask two to three times of how I can bring this attention with comparing notes of the best way to bring my attention. It may be for those who are using the language for policy making but ………" Along these lines, engineer 2 mentioned: "Even though I have the technical skills, I prefer to stay away from the public policy because I am not familiar with public policy process." This demonstrates that one of the obstacles to engineers' participation and influence is the lack of public policy knowledge. By reviewing engineers' education curricula, in the USA educational system, engineers are not exposed to any courses related to public policy. The integration of public policy courses into engineers' education is vital, especially so that engineers recognize that the technical details matter in many policy issues. To further illustrate this point, the researcher refers to studies discussing the relationship between knowledge and performance. Performance within a specific field is

Proposition 2: If engineers are knowledgeable about public policy, they will be more motivated to participate in public decision making.

impacted by knowing this domain (Anderson, 1982). For instance, in a marketing context, Weitz, Sujan, & Sujan(1986) found that a salesperson who is knowledgeable about the business domain practices sales effectively. Along a similar vein, in the context of education, Tai-Seale's (2000)

Proposition 2: If engineers are knowledgeable about public policy, they will be more motivated to participate in public decision making.

study demonstrated that students' participation in classrooms is associated with their preparation and familiarity with the subject. Therefore, this research suggests the following:

Leadership

In the literature studying organizational behavior, various views associated leadership to personal capability, as well as the environment in which the person find himself (Messick & Kramer, 2004). In the context of engineering, leadership is important as it has become necessary to make changes in an environment where there is growing interdependence between technology, society, and public policy. Accordingly, this change can only come about if engineers take an active role and assume leadership positions (Clough, 2004) by possessing leading main change features (Yukl, 2002).

Engineer 2 stated, "I don't see engineers being in that role because generally, engineers do not attain the same level of executive leadership." Thus, we may propose the following:

Proposition3: Leadership is important in making appropriate public decision making.

This proposition was also concluded from the statement of engineer six who stated that "The lack of influence is related to the fact that most of the decision makers are not engineers but from other backgrounds. These people are leaders who have more power, and even if they get some assistance from engineering organizations, they have the last say." This participant has associated the influence to not only leadership but also the position of power.

Power

Scholars in other domains discussed power. In the business field, for example, Smith et al. (2008) argued that when an individual has a position of power, he makes more effort and feels more confident making decisions related to complex issues. " Engineer 5 specified that "to influence public decisions, engineers should get in decision-making positions or government positions, they should act as leaders and to do that they need to be in a position of power." Considering the government as a public organization, we may propose the following:

Proposition 4: Being in a position of power impacts the motivation of engineers

to influence public decision making

Responsibility

Responsibility is listed as one of the four R's of motivation; responsibilities, rewards, reasons, relationship; in research technology management, Maccoby (2015) stated that the motivation of people increases when their responsibilities are reminiscent. For example, the responsibility to build something related to implement a strategy is a motivator for managers. In another study, Herzberg (1968) stated in his theory that job design and responsibility are factors that affect motivation positively. This is coherent to the interviewees' statements. One of the interviewees, engineer 6, mentioned that: “I feel that I have a responsibility to make sure that the decision related to engineering are efficient, the reason why it is important to be part of the decision-making process”. Similarly, engineer 2 also argued, “ as an engineer, you have the responsibility to present the technical data professionally…”

Thus, we propose the following:

Proposition 5: Perceived responsibility increases the motivation to participate in decision making.

Ability factors

Several studies have examined the relationship between ability and influencing decision making within the various fields, such as business, finance, and healthcare. Accordingly, Parker and Fischhoff (2005) developed a set of measurements, including resistance to framing, application of decision rules, risk perception consistency, that are correlated with competencies and which affect the decision process. This present study is the first to explore in depth the constituents of engineers’ ability influencing decision making within public organizations (Figure 23 illustrates the findings). The key drivers identified are Knowledge and soft skills.

Knowledge

Knowledge emerged as the primary factor enabling engineers to influence decision-making. Two subcategories are discussed, including technical skills and risk management.
In the literature related to financial decisions, Perry and Morris (2005) reported that the availability of resources is positively correlated with the person’s behavior, and consequently the person’s choice. Along the same lines, authors in the management field stated that using

managerial skills affect the results of the managers' decisions (Mayer & Davis, 1989). This supports engineer two who reported that "Engineers have the knowledge and experience to make better decisions…." Engineer three similarly declared that "engineers by both education and personality analyze problems and find solutions in a rational, systematic way. The entire engineering mindset is to define a problem, identify alternatives, select the best solution, and then implement the most beneficial solution. Engineers are knowledgeable about an array of subjects including business, public health, and technology." This statement is supported by a study related to personal decision making. Engineer 7 stated, "Engineers often have superior knowledge of current scientific issues as compared to career politicians who can be extremely useful when debating legislation regarding emission guidelines from automobiles, clean water, energy policies, and air pollution mandates. The engineer's ability to think and devise solutions to problems is a unique quality enabling him/her to influence public policy." This engineer explains the ability "technical knowledge related" of engineers to make decisions related to the field. This is in alignment with studies discussing the relationship between knowledge and performance where performance within a specific field is impacted by knowing this domain (Anderson, 1982). As stated in the previous section, Weitz et al. (1986) found that salesperson who is knowledgeable about business domain, practice sales effectively. Therefore, we suggest the following:

Proposition 6: Gaining technical skills is positively correlated with effective decision making within public organization, and engineers have the knowledge and experience to make the appropriate decisions.

Furthermore, in dynamic social studies, Fuller, et. al., (2012) found that the perception of ability positively impacts decision making in an organization, which was mentioned by engineer 2, who stated, “I believe that I have valuable skills that can make governmental organization make a better decision.” This clarifies that this participant has confidence in his ability to influence a governmental decision. This affects not only his motivation but will also affect his behavior towards making a change. Thus, we propose the following:

Proposition 7: Technical knowledge perception affects decision making

In addition to the relationship between technical skills and ability to influence public decision-making suggested in propositions 1 and 2, we discuss the ability to manage risk and its relation to influence.

Risk management in public decision-making implies having the capacity to not only identify the nature of risk, but find appropriate responses (Bouder & Beth, 2003) as well as list risk reduction options (FEMA, 2015). Various tools are available to reinforce the implementation and execution of risk management, including the Preliminary Hazard Analysis, Hazard and Operability Analysis, Job Safety Analysis, Failure Mode and Effects Analysis, Fault Tree Analysis, and Cause and Consequences Analysis (Pinto et al. 2015). Engineers, experienced and knowledgeable in risk management will be able to identify risk, analyze it, prioritize it, develop it, and assures that risk information is well communicated (Dorofee et al., 1996). Engineers may use these techniques to play a key role in effective risk management. This was clearly stated by various interviewees.

One noted remark from Engineer 10 who stated ”…. coming up with objective statements of risk and models of risk that are not biased that in some way can objectivity be for minimizing bias from reality and then publishing those and being consistent to those”. In the same veins, engineer 4 confirmed that "engineers are uniquely positioned to minimize risk and take safety as the utmost importance".

Thus, we propose the following:

> Proposition 8: Risk management is an important skill that engineers possess, and the possession of it impact decision making.

Eight out of 13 engineers explained that having enough knowledge is not enabling them to participate and influence decision making effectively. They discussed that making a difference necessitates developing personal attributes and communication skills, which the research categorized as soft skills. The next section provides a discussion of the soft skills.

Soft skills

This section examines the association of soft skills to the influence on public decisions. In finance, authors specified some important softs skills that should be masters, including communication (Dixon, Belnap, Albrecht, & Lee, 2010). In social and organizational psychology areas, choosing a specific type of communication is important. It can either be task-focused and socio-emotional which in both cases increases effectiveness of decisions (Enayti, 2002). Within the interview process, most of the engineers declared that one of the obstacles to their involvement in public decision making or to their influence is the lack of communication. Engineer 8 stated, "Sometimes I feel that I lack communication skills, or maybe I feel like people in other fields communicate better which helps them," and engineer 10 stated, "Communication is a key. Communicate with their respective lawmakers in their respective state and county, no matter whether the Engineer wishes to personally become active in the political decision process or not. This I believe will open wider avenue". This proves that one of the obstacles of engineer's participation and influence is the lack of communication. Therefore, we suggest:

Proposition 9: Communication skills have to be improved in order to influence decision making.

Furthermore, in various studies related to management research, scholars stated that personal attributes affect decision-making (Mehrabi & Kolabi, 2012), which supports what one of the interviewees stated, “Many decisions are based on the personal attributes such as attitudinal factors and motivational factors of the decision maker.” This was also proved in the previous section discussing the motivational factors impacting public decision-making. Thus, we propose

Preposition 10: Personal attributes are important factors that affect the way engineers can influence decision making.

Opportunity Factors

According to the literature review, some engineer’s members of organization, such as ASCE, work for government organizations and provide advices to policy makers. However, they are not involved in policy related decisions (ASCE Report, 2014), and their advice is not always considered.

In the same manual, the authors stated that the involvement of engineers within the execution phase of decision-making and the policy formulation should be of equal importance. Many of the engineers who were interviewed believe that the non-involvement of engineers early in the process may lead to major issues. Engineer 4 stated, “But if that decision-making process was made to resemble more the systems engineering process of decision analysis maybe there are some things that politicians might miss that we could catch”. Therefore, we propose:

Proposition 11: engineers need to be in positions where they can be involved in all the decision-making process not only the policy implementation.

Other than the participation opportunity, the researcher discussed the learning opportunity. When the interviewer asked the participants about the extent to which engineering programs at school prepare future engineers to prepare for public policy, the answer was zero. Engineer 8 stated, “Seriously, we as engineers have come out of an epistemology where as political science comes out of constructivism. It is perceptual, and we really have not had in like 40 something years we haven’t had interaction within engineering or the inclination nor the former approach to political engineering. What you’re asking here is a totally wide-open field that hasn’t been treaded or been acknowledged. We haven’t really stepped into the arena of how do we engineer the political process. […] In the 1950s, we had engineers and we have managers and then we ask these engineers to become managers. Then they started flailing out because they didn’t know what to do.”

In the engineering field, the adoption of engineering economics and the evolution of courses pertaining to environmental sustainability into mainstream programs proved to be beneficial.

Therefore, we suggest the following:

Proposition 12: Introducing public policy courses in the engineering curriculum will provide engineers with a sense of their role in the public decision-making process

Mapping finding onto theory construction

Theory construction is the last step of this research. Prior to developing a theory, it is important to define it.

Theory: definition

There are two different definitions for theory construction (Charmaz, 2006). From a positivism perspective, developing a theory is based on theoretical concepts explaining the study without including preconceptions (Charmaz, 2006). While from an interpretative point of view, the development of the theory is concerned with understanding rather than explaining and is based on the interpretation of the researcher (Charmaz, 2006). Furthermore, Strauss and Corbin (1998) assert that a theory is "a set of well-developed concepts related through statements of relationship, which together constitute an integrated framework that can be used to explain or predict phenomena." This study will combine both a positivist and interpretative view as the use of grounded theory necessitates developing concepts relationship as well as interpreting them. The research would take a constructive approach.

According to Charmaz (2006), theorizing means stopping, pondering and rethinking anew. This means that the researcher will have to look various perspectives (Charmaz, 2006), use comparisons, delimit the theory, and then write it (Glaser & Strauss, 1967, p.105).

Theorizing socio-political engineering

In contrast to deductive approaches in which researchers test hypotheses, within this inductive approach, based on participants views and experiences, new theory is developed. The following figure represents the generated theory.

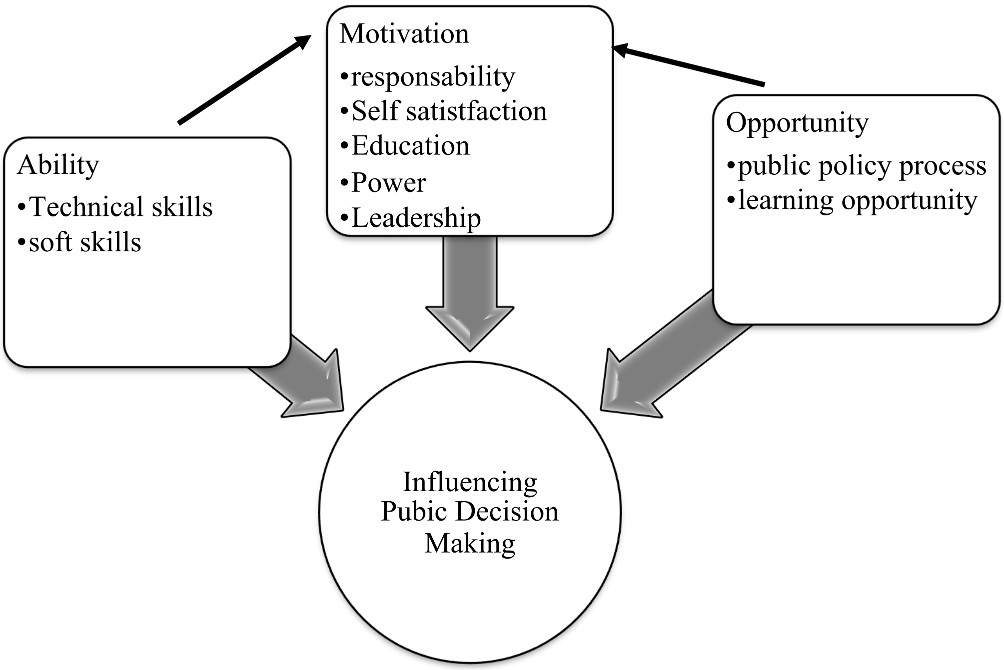

Figure 22: Theory Development: Socio-Political Engineering

Conclusion: Influencing public policy is a function of the interaction between an engineer's motivation, ability, and opportunities.

This figure highlights the importance of various factors to the influence of engineers on public policy. By studying each concept and its categories separately, it has been concluded that they serve as necessary but not as sufficient for the influence to happen. For instance, if an engineer has all the technical skills (ability) to participate in a public decision making but lacks a position of power (opportunity), a change may still occur. Thus, the importance of ability, motivation, and opportunity as separate concepts was established. However, to make better decisions, there should be an interaction and combination of the concepts. As shown in Figure 12, the technical skills and soft skills (ability) may be antecedents' conditions to engineer's ability to affect public decisions. For instance, some engineers stated that their perceived ability or what they also called personal power is one of the factors that encourage them to make their voice heard.

CHAPTER 6

CONCLUSIONS, LIMITATIONS, AND RECOMMANDATIONS

This final chapter considers the contribution of the study the results obtained, the implications for research and practice, limitations, and future research directions. The first section presents a summary of the thesis, the second section considers the different types of contributions, and the third section proposes the limitations as well as the possible research directions.

Introduction

Research related to engineering and public policy is limited, especially regarding the influence of engineers on the public policy process. Despite the widely acknowledged importance of engineers in public policy, engineers' participation is restricted, and the main actors are lawyers and social scientists. However, engineers' lack of involvement affects both the profession and the interest of the nation.

A search of the literature clearly demonstrates that there are still significant gaps in this research area, as evidenced by continued calls in the literature for additional investigation of the issue. This study attempts to fill this gap by developing a new theory "Socio-political Engineering" and providing the first overarching theoretical framework detailing the skills necessary for engineers to navigate effectively within organizations and society, as well as influence policy decisions, and the different factors impacting their influence.

The research first posed three key research questions:

- What are the constituent elements of sociopolitical engineering, and what attributes and dimensions characterize these elements?
- What framework can be developed for constructing and articulating sociopolitical engineering?

- What is the engineers' perception about their influence on public policy?

By building on a grounded theory approach and the M-O-A framework, the research uncovered answers for these questions, and developed a theory of socio-political engineering. Interview analysis was conducted using both NVivo software and Q factor analysis. This chapter summarizes the findings of each phase of the study, identifies its limitations and provides recommendations for future research.

Summary of the findings

Grounded in the data collected, the researcher developed a theory of study explaining the factors that affect the influence of engineers on public policy. Using a specific coding process and her own ability to analyze the data (DeNardo & Levers 2002), the researcher started by reading the participants' answers and developing categories. The creation of these codes followed the two methods. The first one is based on coding without any a prior knowledge (Glaser & Strauss 1967); then, a second method was used to reduce categories based on the theoretical model of the instrument (Miles & Huberman, 1994). Subsequently, these categories were integrated as a new theory.

The new theory suggests that, in order for engineers to influence public policy, they should possess technical and soft skills, and they should be given the opportunity to engage with policy decision. Their ability and opportunity are both correlated with their motivation to influence public policy.

Whether they have a position within the government or not, engineers' influence is vital. As an external source, the advice they provide to the governmental organizations is effective if the organizations seek it in the appropriate stage of policy making. Furthermore, it is important to educate engineers about public policy to make sure that they are well equipped both technically and legally to be able to provide advice across both disciplines.

The researcher suggests the introduction of public policy courses in engineering programs to expose future engineers to public policy concepts and give them an insight on the importance of such an interaction between the two fields.

Ethical considerations

Given the sensitivity of the data that is collected through qualitative instruments, ethical issues must be taken into consideration at each of the research phases. For this study, the researcher applied for an ethical permission to proceed with the interviews. The application consisted of an electronic IRB exemption application, study proposal, consent form, data collection protocol and a list of references. The IRB exemption was approved, and the researcher was able to start her research (Appendix 4). A consent form was developed (Appendix 3) and handed out to respondents before the start of the interview for two purposes. The primary objective of this document is to acknowledge that the confidentiality rights of the respondents are protected, and no information will be delivered to third parties. To guarantee the anonymity of the participants, the names of participants is not revealed, the researcher assigned specific titles, as “engineer 1”, “engineer 2” to respondents, and only these titles appeared in the result section. Second, the form aims at obtaining the respondents' consent to publish their statements but in an anonymous way. Furthermore, to ensure the confidentiality of the data collected, the researcher saved the data in a laptop as well as an external drive; both were password protected, in accordance to data protection regulation in the United States of America.

Theoretical contributions

Few studies were done in relation to engineering and public policy, but they were limited by their descriptive and editorial approach, rather than analytic and empirical approach, respectively. This framework contributes to the understanding of socio-political engineering by developing an integrated theory of engineers' participation in public policy making. The framework explicates specific, identifiable aspects pertaining to engineers' motivations, abilities, and opportunities to participate in public policy decision-making. Thus, this research has explicated the constituents of socio-political engineering as identified in the initial research questions. The framework that emerged explicates the "why" and "how" of engineers' involvement by showing the challenges and obstacles preventing them from participating in decisions making, the skills motivating them to act, and the opportunities presented to them.

This study covers the significant gap in the literature by using a novel research design. The use of grounded theory has been growing in recent years. It has also been seen that Grounded Theory can be used to explain and understand the behavior of engineers when it comes to public decision-making. Thus, this research adds to the body of empirical evidence that suggests that both qualitative research methods, in particular grounded theory, can be used as valid methods of investigation in the engineering and public policy fields. Furthermore, the grounded theory approach has proven to be appropriate for use and resulted in a clearer picture of engineers' influence on public policy. To further emphasize the results of coding, the researcher integrated a quantitative analysis to study the subjectivity of engineers in relation to this topic. This enabled the researcher to develop a new theory of study, "Socio-political engineering," which aimed to add to the body of knowledge by demonstrating the criteria that play a role in bridging the gap between engineering and public decision making.

Practical contributions

In addition to the theoretical and methodological contribution, this study demonstrates a significant practical contribution to governments that are deploying efforts to improve society by integrating technological advancements. However, this requires the involvement of people who are experts in the deployment and maintenance of these technologies. Therefore, engineers' involvement has become a necessity. This study, therefore, makes a contribution to practice by helping governmental institutions understand the underlying factors related to engineers' participation in public policy making. The results of this study can encourage the different levels of government to give more opportunities to engineers in order to prove their capabilities in shaping decisions.

The study's findings are also essential to universities, which should include public policy programs in their curriculum. It is imperative for future engineers to understand how public policy affects them and how their skills and abilities are important for the development of policies.

Taken together, this discussion also highlights that, in order to make better decisions with minimized risks, there should be collaboration among stakeholders (i.e. universities, governmental bodies, and engineers) to better understand the needs of each, and effective strategies to better prepare engineers to the public policy.

Limitations and future research directions

"The end of a work such as this should signal neither a conclusion nor a final word, but rather a punctuation in time that marks a stop merely to take a breath" (Lincoln & Denzin, 2005, p. 1115). Having highlighted the study's key contributions, it is important to reflect upon the research's limitations that need to be taken into consideration when considering the study's findings. However, even though the current study has many limitations, those limitations do not mitigate the vitality of the research's results, rather enrich them, giving the possibility to critiques, and avenues for future research directions.

First, the development of the theory was based on the experience of 13 engineers, which is a small sample size, and it may be considered as a limitation. However, the researcher used grounded theory where the sample size is not specified until the research begins the interview process and has reached "saturation." Moreover, in this study, only the perspective of engineers has been considered; therefore, a fertile avenue for future research is to examine the implication of engineers from the perspective of governmental agencies to better understand how the latter perceives engineers' participation.

Second, the results of this study are based on the American system. Although this allowed the researcher to control for contextual variables, it limits the generalizability of the findings to other countries. However, generalizability is not of great concern when it comes to qualitative research approaches, and there is no method that can grasp the subtle differences in engineers' experiences. Accordingly, conducting a cross-country study to examine engineers' implication in various public policy making settings would prove valuable in further substantiating the findings of this study.

Finally, the objective of the present research was to develop theory rather than test theory. The researcher aimed at exploring the unchartered territory of socio-political engineering by using grounded theory, which was deemed suitable from both the theoretical and methodological viewpoints. Further research could be undertaken by extending to a larger cross-sectional study in the form of a questionnaire. Thus, I encourage researchers to empirically validate the suggested set of propositions through a survey-based approach.

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Appendix 1: Interview protocol

<u>Interview protocol</u>

Question category	Objective	Interview question
General questions	Understanding the involvement of PEs in public decision making	● How long have you been working as an Engineer/Professional Engineer (PE) ● Have you ever been involved in politics as a professional capacity?
Warm-up questions	Perception of PEs	● As an Engineer/Professional Engineer (PE), how do you perceive your right to participate in PE issues? ● As an Engineer/Professional Engineer (PE), how do you perceive your importance to participate in engineering issues?
Motivation-related questions	Determining the factors impacting PEs motivation	● What avenues does an Engineer/Professional Engineer (PE) have, to get more involved in public policy issues? ● Why might an Engineer/Professional Engineer (PE) choose be involved in public policy issues? ● What are the benefits to an engineer who is participating in public decision-making? o What are they? ● Why might an Engineer/Professional Engineer (PE) choose to not be involved in the political process? ● Why might an Engineer/Professional Engineer (PE) should be attracted the political process?

		• How can an Engineer/Professional Engineer (PE) be encouraged to participate in the public decision process? • Are there any challenges facing an Engineer/Professional Engineer (PE) in public decision-making, under the American political landscape? What are they?
Ability-related questions	Determining the factors impacting PEs Ability	• How can an Engineer/Professional Engineer (PE) overcome these challenges to ensure that his/her work influences public decision-making? • Why might government look to an Engineer/Professional Engineer (PE) for technical guidance? • Does an Engineer/Professional Engineer (PE) possess qualities enabling them to influence public policy? What are these qualities? • In what capacity can a an engineer/ PE participate in public policy decision making? • How can PEs improve the quality of the government? • In the light of engineerss obligations, public safety is of utmost importance. How can the effort of an Engineer/Professional Engineer (PE) in the public decision-making process minimize risks? • How do you, as an Engineer/Professional Engineer (PE), perceive risk in engineering-related issues?

		• What strengths might you, as an Engineer/Professional Engineer (PE), bring to a public decision-making process? • To what extent are engineering programs (schools) preparing future engineers for understanding public policy? • When an engineer participates in public decision-making, are there benefits to society?

Opportunity-related questions	Determining the opportunities provided	• In which stage of the decision-making process are an Engineer/Professional Engineer (PE) involved?
		    • Engineers typically wait for a political decision and then engage in implementation. Do you think PEs involvement should be prior to that?
		    • In which part they would be more effective?

Concluding questions		• Do you have anything to add? • Are there other aspects that you have thought of during our interview that you think might be important for me to know about your influence in Public policy?

Appendix2: Introductory Message for Participants with Agreement to Participate

Dear [Participant],

We are requesting for your participation on a research study to better understand how professional engineers can influence decision-making and public policy. The study will be based upon information gathered through a series of in-depth interviews with professional engineers. Participating in the interview is voluntary. The interview will be approximately 30 – 60 minutes long and will only be used for academic purposes. There is no right or wrong answer to any of the questions, and you may decline to answer any questions you do not want to answer or terminate the interview at any time. However, it is necessary that respondents participate and respond in an honest fashion to the best of their ability and knowledge.

Interview data will be secured and accessible only to the principal and co-principal investigators of this research study (Dr. Charles Daniels and Sarah Bouazzaoui). You may terminate the interview at any time.

If you have any questions or would like to obtain additional information about this research study, please feel free to contact the co-principal investigator, Sarah Bouazzaoui, by email at sboua003@odu.edu, or in person at the Graduate Assistant Lab, Engineering Systems Building, Old Dominion University, Norfolk, VA 23529.

For questions regarding the Institutional Review Board and the current research protocol, please contact the chair of the Batten College of Engineering and Technology IRB committee, Dr. Stacie Ringleb, at 757-683-5932 or the Old Dominion University Office of Research at 757-683-3460.

I am truly grateful for your participation and contributions to this research study.

Sincerely,

Sarah Bouazzaoui

Appendix3: Informed Consent Document

OLD DOMINION UNIVERSITY

PROJECT TITLE:
SOCIOPOLITICAL ENGINEERING: THE INFLUENCE OF PROFESSIONAL ENGINEERS ON PUBLIC POLICY

INTRODUCTION
The purposes of this form are to give you information that may affect your decision whether to say YES or NO to participation in this research, and to record the consent of those who say YES. This research project seeks to define and articulate sociopolitical engineering and how is it used by Professional Engineers to influence public policy

RESEARCHERS
Charles Daniels, Ph.D is a senior lecturer at the Engineering Management & Systems Engineering

Sarah Bouazzaoui is a Ph.D candidate Engineering Management and Systems Engineering. Old Dominion University.

DESCRIPTION OF RESEARCH STUDY

The need for engagement and involvement by Professional Engineers is of great significance for setting sound public policy and monitoring complex technical issues in the society. In this research, the focus will be on the exploration of how professional engineers can influence decision-making and public policy. Researcher uses a constructive grounded theory and a theoretical framework M-O-A Motivation-Opportunity-Ability to guide the inquiry. This study contributes to the literature in three important ways. First, it bridges the gap between engineering and public policy-making research. Second, the study extends to use of the MOA framework to a novel context by focusing on engineers' influence on public policy. This will contribute to the research methodologies in engineering management where grounded theory is of limited use. In fact, inductive research should be improved in areas related to engineering management, such as decision-making, and complex systems issues. Lastly, this knowledge will provide insight into ways that socio-political engineering may enhance engineering education and PE certification through development of capabilities to influence public decision-making. Research in socio-political engineering will enable addressing problems where knowledge of technical details and engineering principles is critical to decision making.

The study will be based upon information gathered through a series of in-depth interviews with professional engineers. Participating in the interview is voluntary. The interview will be approximately 30 – 60 minutes long and will only be used for academic purposes. There is no right or wrong answer to any of the questions, and you may decline to answer any questions you do not want to answer or terminate the interview at any time. However, it is necessary that respondents participate and respond in an honest fashion to the best of their ability and knowledge. Key points of the interview include:

- The participation of professional engineers in public policy process
- The factors affecting the motivation of professional engineers to influence public policy process

- The different skills required to effectively and efficiently impact and influence public policy process
- The opportunities given by the government to enable the participation of professional engineers in public policy

As part of this interview, I would like to audio record your responses using a digital recorder. The digital recordings will be erased once they are transcribed into an electronic word document, and that word document will stored in an encrypted file. All names in the transcription (both individual and company names) will be replaced with aliases during the transcription process to ensure your anonymity. If you have any questions about the audio recording and transcription process, please contact me at 757 352 7666 or sbouazza@odu.edu

RISKS AND BENEFITS

There are no direct benefits to you for participating, but you will be contributing to our knowledge of an important research topic. After completion of the study, I will provide you with a consolidated report on justice issues in buyer-supplier relationships. On the other hand, there are no risks to you for being involved, and ALL information and responses will remain confidential.

COSTS AND PAYMENTS

The researchers want your decision about participating in this study to be absolutely voluntary. Your participation will not pose any costs or inconvenience.

NEW INFORMATION

If the researchers find new information during this study that would reasonably change your decision about participating, then they will give it to you.

CONFIDENTIALITY

The researchers will take necessary steps to keep private information. The interview's answers will be confidential. To guarantee the anonymity of the participants, The names of participants will not be revealed the researcher will assign specific titles, as “Professional Engineer 1”, “Professional Engineer 2” to respondents and only these titles will appear in the result section. The results of this study may be used in reports, presentations, and publications; but the researcher will not identify you. Of course, your records may be subpoenaed by court order or inspected by government bodies with oversight authority.

WITHDRAWAL PRIVILEGE

It is OK for you to say NO. Even if you say YES now, you are free to say NO later, and walk away or withdraw from the study at any time. Your decision will not affect your relationship with Old Dominion University, or otherwise cause a loss of benefits to which you might otherwise be entitled. The researchers reserve the right to withdraw your participation in this study, at any time, if they observe potential problems with your continued participation.

COMPENSATION FOR ILLNESS AND INJURY

If you say YES, then your consent in this document does not waive any of your legal rights. However, in the event of harm arising from this study, neither Old Dominion University nor the researchers are able to give you any money, insurance coverage, free medical care, or any other compensation for such injury. In the event that you suffer injury as a result of participation in any research project, you may contact Dr. Charles Daniels, the responsible principal investigator, Dr. Tancy Vandecar-Burdin the current IRB chair at 757-683-3802 at Old Dominion University, or the Old Dominion University Office of Research at 757-683-3460 who will be glad to review the matter with you.

VOLUNTARY CONSENT

By signing this form, you are saying several things. You are saying that you have read this form or have had it read to you, that you are satisfied that you understand this form, the research study, and its risks and benefits. The researchers should have answered any questions you may have had about the research. If you have any questions later on, then the researchers should be able to answer them:

Charles B Daniels. Email: cbdaniel@odu.edu
Sarah Bouazzaoui. Email: sbouazza@odu.edu

If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call Dr. Tancy Vandecar-Burdin, the current IRB chair, at 757-683-3802, or the Old Dominion University Office of Research, at 757-683-3460.

And importantly, by signing below, you are telling the researcher YES, that you agree to participate in this study. The researcher should give you a copy of this form for your records.

Subject's Printed Name & Signature	**Date**
Parent / Legally Authorized Representative's Printed Name & Signature (If applicable)	**Date**
Witness' Printed Name & Signature (if Applicable)	**Date**

INVESTIGATOR'S STATEMENT

I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and any experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely entice this subject into participating. I am aware of my obligations under state and federal laws, and promise compliance. I have answered the subject's questions and have encouraged him/her to ask additional questions at any time during the course of this study. I have witnessed the above signature(s) on this consent form.

Investigator's Printed Name & Signature	**Date**

Appendix 4: Exemption from IRB review

DATE: March 13, 2017
TO: Charles Daniels, Ph.D. FROM: Old Dominion University Engineering Human Subjects Review Committee
PROJECT TITLE: [1014476-3] Socio-Political Engineering The influence of professional engineers on public policy REFERENCE #: ENGN 17-01
SUBMISSION TYPE: Amendment/Modification
ACTION: DETERMINATION OF EXEMPT STATUS
REVIEW CATEGORY: Exemption category # 6.2

Thank you for your submission of Amendment/Modification materials for this project. The Old Dominion University Engineering Human Subjects Review Committee has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations. We will retain a copy of this correspondence within our records. If you have any questions, please contact Stacie Ringleb at 757-683-6363 or sringleb@odu.edu. Please include your project title and reference number in all correspondence with this committee.
This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Old Dominion University Engineering Human Subjects Review Committee's records

Appendix 5: Q methods statements

Statements were developed based on the interview answers.

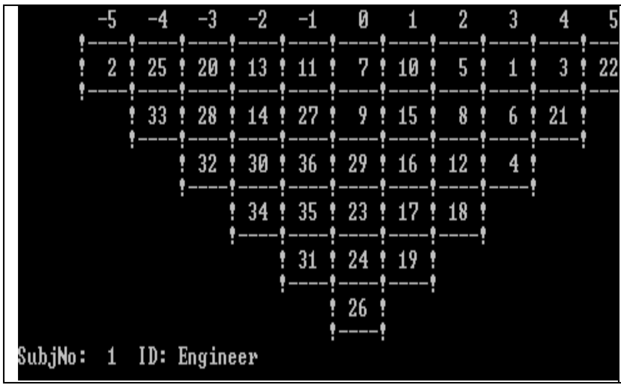
	Statements
1	My participation in public decision making is crucial significant and valuable, because as an engineer I have all the technical skills needed to make the right decision
2	I would participate in public policy for ego reasons just to think of oneself as being important.
3	Positive reason for participation might be when the engineer perceives that the outcome of the decision as it stands currently is missing some insight that he is capable of providing
4	Engineers may choose to be involved in public policy because they are better positioned in introducing engineering approaches such as problem solving and risk assessment and mitigation - into the legislative, public policy processes and policy issues thus enhancing the viability of a denied policy.
5	I mean public policy affects you on a direct level so if you're one interested in it or two feel like you could make a difference then you should get involved
6	If engineers were involved in public policy issues we would have a technical perspective. I think most engineers are very objective and not based on opinion but based on knowledge
7	Engineers need to be placed in lawmaking as part of the process rather than a requirement.
8	The benefits of an engineer participating in public decision-making is: • He/she can take the tangible benefits of science, engineering, and technology to people's lives, this is a fulfilling and gratifying benefit from an engineer perspective
9	The political process or decision-making process is frustrating and requires time
10	You have to make the effort to be heard and if you give up then you don't have the motivation to participate or someone shuts you out
11	Sometimes we choose not to participate because of cynicism, not believing it that it would help. The second reason would be believing that it may help but not agreeing with the outcome.
12	The lack of understanding of what an engineer can and cannot do in a political process

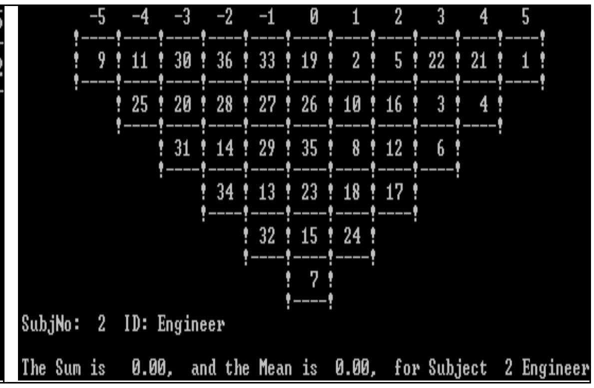
13	The uncomfortable feeling of many of the Engineers to stand up and speak out on public policy issues during political process.
14	Engineers are so driven on their own career life.
15	The entire engineering mindset is to define a problem, identify alternatives, then implement the most beneficial solution
16	I reflect for myself, Am I qualified enough to voice my concern? Lack of education that comes to policy making. I have to ask two to three times of how can I bring this attention with comparing notes of the best way to bring my attention
17	To influence public decisions, some engineers should get in decision-making positions.
18	the opportunity to get involved in politics wasn't given to me, nobody has ever told me get involved
19	Engineers by both education and personality analyze problems and find solutions in a rational, systematic way
20	I might have some influence in some situations but not what I would call major decisions.
21	I think other professions have more means of influence than engineers. For example, I guess lawyers or business executives would be more influential and in the US particularly, I think business executives and rich people in general are very influential because they can fund campaigns and use that funding as a means of influence
22	Engineers often have superior knowledge of current scientific issues as compared to career politicians which can be extremely useful when debating legislation regarding emission guidelines from automobiles, clean water, energy policies, and air pollution mandates
23	I would say as an external expert, I would say that's the main role that i can see, or as a member of government bodies who provide advice
24	Because of the high ethical standard they implement in their profession and the superior knowledge of current scientific issues, engineers are uniquely positioned to minimize risk and take safety as the utmost importance
25	I feel like all the risks that they would minimize would be on a smaller scale
26	I perceive risk as an element that can not be eliminated but can be minimized by taking the necessary measures and conducting a robust study prior implementing a project or making a decision
27	If decision making process was made to resemble more the systems engineering process of decision analysis maybe there are some things that politicians might miss that we could catch.
28	we as engineers have come out of an epistemology where as political science comes out of constructivism.

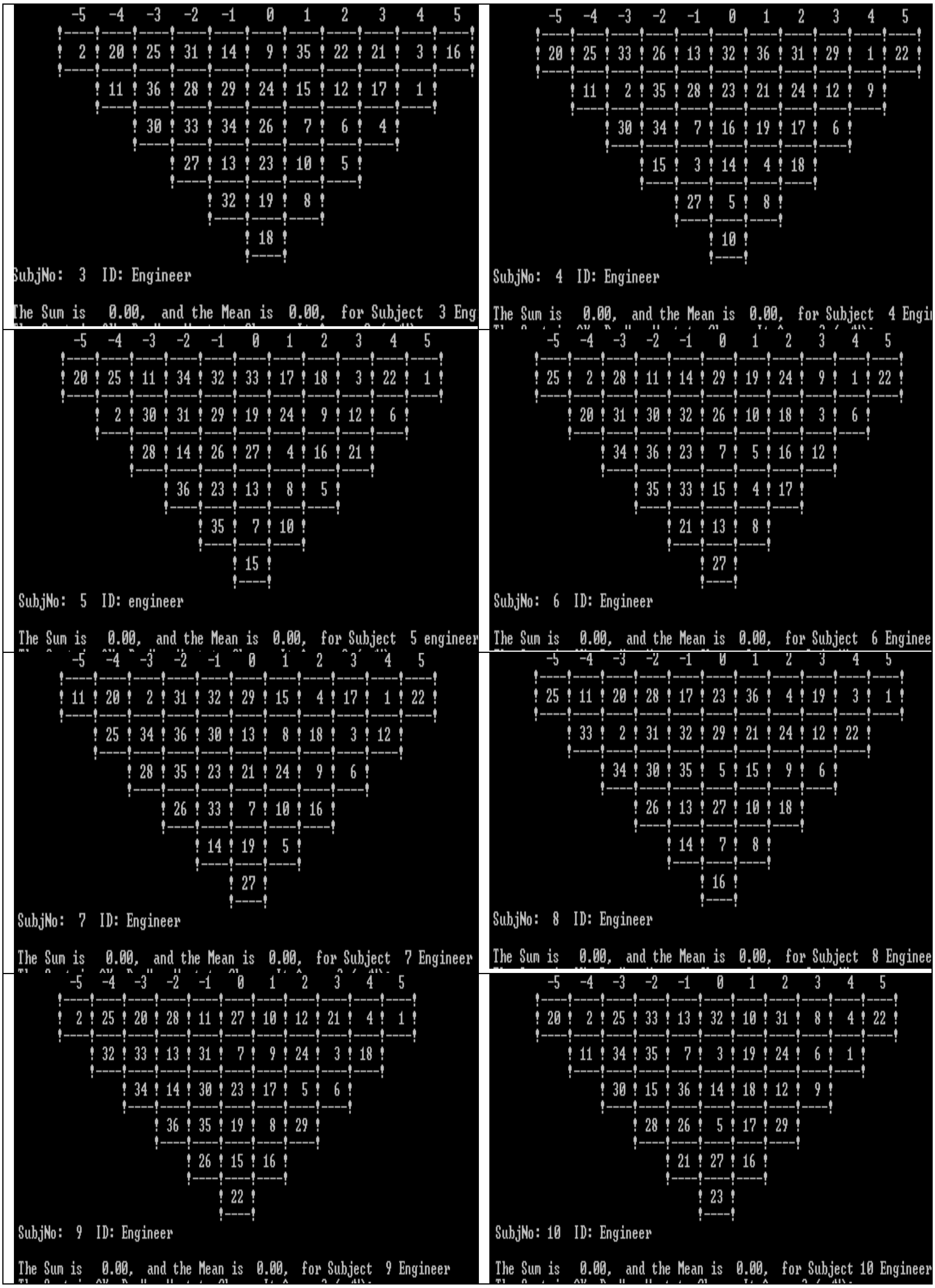
29	Society would benefit from decisions based on sound factual scientific evidence
30	I would say having decisions of higher quality, and broader than what politicians and the engineers that they hire, is one of the problems with the expert institutions that support decision making is that those people generally are nominated by the political power so they don't have the dependence
31	if you look at flint. Engineers who knew about all the problem there weren't taken seriously by the government there. If they were more engaged in that, possibly there would be taken action much sooner and there wouldn't be people drinking contaminated water for two years
32	I would think engineers are mostly involved in the implementation stage of decision making.
33	I don't think engineers should be involved very early in decision making process; it should be planners. Planners have the concept and the view to build or construct something. And then the engineers come in to validate or de validate that planning
34	the phases that come before are phases that concern the citizen that is, like identifying a problem or setting an agenda, and an engineer can be very helpful in those phases
35	I think the engineers should participate but participate as a citizen and those things should actually be taken out of the hands of the politician, but also out of the hands of the engineers, they should be given to the people
36	in my opinion, is not about solving the problems, it's about determining as humans what problems should we care about and what are the things that should motivate us towards actions and that's where we mostly suffer

Appendix 6: Q Sorting Results of The Participating Engineers

Screenshots of Q Software






-5 -4 -3 -2 -1 0 1 2 3 4 5
2 20 25 31 14 9 35 22 21 3 16
11 36 28 29 24 15 12 17 1
30 33 34 26 7 6 4
27 13 23 10 5
32 19 8
18
SubjNo: 3 ID: Engineer
The Sum is 0.00, and the Mean is 0.00, for Subject 3 Eng
-5 -4 -3 -2 -1 0 1 2 3 4 5
20 25 33 26 13 32 36 31 29 1 22
11 2 35 28 23 21 24 12 9
30 34 7 16 19 17 6
15 3 14 4 18
27 5 8
10
SubjNo: 4 ID: Engineer
The Sum is 0.00, and the Mean is 0.00, for Subject 4 Engi
-5 -4 -3 -2 -1 0 1 2 3 4 5
20 25 11 34 32 33 17 18 3 22 1
2 30 31 29 19 24 9 12 6
28 14 26 27 4 16 21
36 23 13 8 5
35 7 10
15
SubjNo: 5 ID: engineer
The Sum is 0.00, and the Mean is 0.00, for Subject 5 engineer
-5 -4 -3 -2 -1 0 1 2 3 4 5
25 2 28 11 14 29 19 24 9 1 22
20 31 30 32 26 10 18 3 6
34 36 23 7 5 16 12
35 33 15 4 17
21 13 8
27
SubjNo: 6 ID: Engineer
The Sum is 0.00, and the Mean is 0.00, for Subject 6 Enginee
-5 -4 -3 -2 -1 0 1 2 3 4 5
11 20 2 31 32 29 15 4 17 1 22
25 34 36 30 13 8 18 3 12
28 35 23 21 24 9 6
26 33 7 10 16
14 19 5
27
SubjNo: 7 ID: Engineer
The Sum is 0.00, and the Mean is 0.00, for Subject 7 Engineer
-5 -4 -3 -2 -1 0 1 2 3 4 5
25 11 20 28 17 23 36 4 19 3 1
33 2 31 32 29 21 24 12 22
34 30 35 5 15 9 6
26 13 27 10 18
14 7 8
16
SubjNo: 8 ID: Engineer
The Sum is 0.00, and the Mean is 0.00, for Subject 8 Enginee
-5 -4 -3 -2 -1 0 1 2 3 4 5
2 25 20 28 11 27 10 12 21 4 1
32 33 13 31 7 9 24 3 18
34 14 30 23 17 5 6
36 35 19 8 29
26 15 16
22
SubjNo: 9 ID: Engineer
The Sum is 0.00, and the Mean is 0.00, for Subject 9 Engineer
-5 -4 -3 -2 -1 0 1 2 3 4 5
20 2 25 33 13 32 10 31 8 4 22
11 34 35 7 3 19 24 6 1
30 15 36 14 18 12 9
28 26 5 17 29
21 27 16
23
SubjNo: 10 ID: Engineer
The Sum is 0.00, and the Mean is 0.00, for Subject 10 Engineer

Appendix7: Q method results

PQMethod2.35 socio political engineering PAGE 1
Path and Project Name: C:\PQMethod\projects/s Jan 8 18

Correlation Matrix Between Sorts

SORTS	1	2	3	4	5	6	7	8	9	10
1 Engineer	100	74	82	66	85	80	80	83	87	70
2 Engineer	74	100	79	46	76	64	71	67	67	53
3 Engineer	82	79	100	56	85	76	80	70	76	64
4 Engineer	66	46	56	100	74	76	77	78	65	91
5 engineer	85	76	85	74	100	92	91	83	80	77
6 Engineer	80	64	76	76	92	100	94	85	76	81
7 Engineer	80	71	80	77	91	94	100	85	75	81
8 Engineer	83	67	70	78	83	85	85	100	78	78
9 Engineer	87	67	76	65	80	76	75	78	100	69
10 Engineer	70	53	64	91	77	81	81	78	69	100

Unrotated Factor Matrix

SORTS	Factors 1	2	3	4	5	6	7	8
1 Engineer	0.9122	-0.1766	0.2503	-0.0067	0.0010	0.1725	0.1840	-0.0825
2 Engineer	0.7816	-0.4694	-0.1862	0.3156	0.1538	-0.0925	0.0300	-0.0234
3 Engineer	0.8667	-0.3350	-0.1006	-0.0169	-0.2849	0.1594	-0.1300	0.0390
4 Engineer	0.8212	0.4994	-0.0023	0.1984	-0.0363	0.0237	0.0455	0.1559
5 engineer	0.9536	-0.0716	-0.1062	-0.1252	-0.0309	-0.0501	0.1176	0.1472
6 Engineer	0.9331	0.1035	-0.1166	-0.2681	0.0411	-0.0728	0.0520	-0.0763
7 Engineer	0.9448	0.0540	-0.2019	-0.1400	0.0363	-0.0644	-0.0566	-0.0380
8 Engineer	0.9119	0.0994	0.1001	-0.0350	0.3180	0.1468	-0.1437	0.0269
9 Engineer	0.8724	-0.1302	0.4046	-0.0064	-0.0719	-0.2137	-0.0815	0.0237
10 Engineer	0.8622	0.4081	-0.0432	0.1745	-0.1332	-0.0156	-0.0243	-0.1701
Eigenvalues	7.8774	0.8253	0.3487	0.2782	0.2342	0.1437	0.1014	0.0923
% expl.Var.	79	8	3	3	2	1	1	1

Cumulative Communalities Matrix

Factors 1 Thru ....

SORTS	1	2	3	4	5	6	7	8
1 Engineer	0.8320	0.8632	0.9259	0.9259	0.9259	0.9557	0.9895	0.9963
2 Engineer	0.6109	0.8312	0.8659	0.9655	0.9891	0.9977	0.9986	0.9991
3 Engineer	0.7511	0.8634	0.8735	0.8738	0.9549	0.9804	0.9972	0.9988
4 Engineer	0.6744	0.9238	0.9238	0.9632	0.9645	0.9650	0.9671	0.9914
5 engineer	0.9094	0.9146	0.9258	0.9415	0.9425	0.9450	0.9588	0.9805
6 Engineer	0.8708	0.8815	0.8951	0.9670	0.9687	0.9740	0.9767	0.9825
7 Engineer	0.8926	0.8955	0.9363	0.9559	0.9572	0.9614	0.9646	0.9660
8 Engineer	0.8315	0.8414	0.8514	0.8526	0.9538	0.9753	0.9960	0.9967
9 Engineer	0.7612	0.7781	0.9418	0.9419	0.9470	0.9927	0.9994	0.9999
10 Engineer	0.7435	0.9100	0.9119	0.9424	0.9601	0.9603	0.9609	0.9899
cum% expl.Var.	79	87	91	93	96	97	98	99

Factor Matrix with an X Indicating a Defining Sort

Loadings

QSORT	1	2	3
1 Engineer	0.5478	0.4162	0.6727
2 Engineer	0.8621X	0.1928	0.2925
3 Engineer	0.7869X	0.3321	0.3794
4 Engineer	0.1766	0.9025X	0.2794
5 engineer	0.6727	0.5844	0.3630
6 Engineer	0.5525	0.7026X	0.3101
7 Engineer	0.6315	0.6887X	0.2514
8 Engineer	0.4406	0.6471	0.4884
9 Engineer	0.4214	0.3973	0.7787X
10 Engineer	0.2792	0.8689X	0.2809
% expl.Var.	33	38	20

Free Distribution Data Results

QSORT	MEAN	ST.DEV.
1 Engineer	0.000	2.449
2 Engineer	0.000	2.449
3 Engineer	0.000	2.449
4 Engineer	0.000	2.449
5 engineer	0.000	2.449
6 Engineer	0.000	2.449
7 Engineer	0.000	2.449
8 Engineer	0.000	2.449
9 Engineer	0.000	2.449
10 Engineer	0.000	2.449

Factor Scores with Corresponding Ranks

	Statements		Factor1		Factor2		Factor 3	
1	My participation in public decision making is crucial significant and valuable, because as an engineer I have all the technical skills needed to make the right decision	1	1.99	1	1.73	2	2.04	1
2	I would participate in public policy for ego reasons just to think of oneself as being important.	2	-0.55	24	-1.49	33	-2.04	36
3	Positive reason for participation might be when the engineer perceives that the outcome of the decision as it stands currently is missing some insight that he is capable of providing	3	1.46	4	0.13	16	1.22	6
4	Engineers may choose to be involved in public policy because they are better positioned in introducing engineering approaches such as problem solving and risk assessment and mitigation - into the legislative, public policy processes and policy issues thus enhancing the viability of a denied policy.	4	1.56	3	0.9	6	1.63	3
5	I mean public policy affects you on a direct level so if you're one interested in it or two feel like you could make a difference then you should get involved	5	0.86	10	0.1	17	0.82	10
6	If engineers were involved in public policy issues we would have a technical perspective. I think most engineers are very objective and not based on opinion but based on knowledge	6	1.13	7	1.35	4	1.22	6
7	Engineers need to be placed in lawmaking as part of the process rather than a requirement.	7	0.16	17	-0.33	25	0	21
8	The benefits of an engineer participating in public decision making is: • He/she can take the tangible benefits of science, engineering, and technology to people's lives, this is a fulfilling and gratifying benefit from an engineer perspective	8	0.43	12	0.71	11	0.41	15
9	The political process or decision making process is frustrating and requires time	9	-1.33	33	1.43	3	0.41	15
10	You have to make the effort to be heard and if you give up then you don't have the motivation to participate or someone shuts you out	10	0.43	12	0.24	15	-0.41	15
11	Sometimes we choose not to participate because of cynicism, not believing it that it would help. The second reason would be believing that it may help but not agreeing with the outcome.	11	-1.72	36	-1.67	35	-0.41	26
12	The lack of understanding of what an engineer can and cannot do in a political process	12	0.86	10	1.21	5	0.82	10
13	The uncomfortable feeling of many of the Engineers to stand up and speak out on public policy issues during political process.	13	-0.43	23	-0.33	25	-0.82	30
14	Engineers are so driven on their own career life.	14	-0.7	28	-0.1	21	-0.82	30
15	The entire engineering mindset is to define a problem, identify alternatives, then implement the most beneficial solution	15	0.16	17	-0.6	26	0	21

16	I reflect for myself, Am I qualified enough to voice my concern? Lack of education that comes to policy making. I have to ask two to three times of how can I bring this attention with comparing notes of the best way to bring my attention	16	1.35	5	0.35	14	0.41	15
17	To influence public decisions, some engineers should get in decision-making positions.	17	1.03	8	0.78	9	0.41	15
18	the opportunity to get involved in politics wasn't given to me, nobody has ever told me get involved	18	0.27	14	0.73	10	1.63	3
19	Engineers by both education and personality analyze problems and find solutions in a rational, systematic way	19	0	20	0.38	13	0	21
20	I might have some influence in some situations but not what I would call major decisions.	20	-1.46	34	-2.05	36	-1.22	33
21	I think other professions have more means of influence than engineers. For example, I guess lawyers or business executives would be more influential and in the US particularly, I think business executives and rich people in general are very influential because they can fund campaigns and use that funding as a means of influence	21	1.56	3	0	18	1.22	6
22	Engineers often have superior knowledge of current scientific issues as compared to career politicians which can be extremely useful when debating legislation regarding emission guidelines from automobiles, clean water, energy policies, and air pollution mandates	22	1.13	7	2.16	1	0	21
23	I would say as an external expert, I would say that's the main role that i can see, or as a member of government bodies who provide advice	23	0	20	-0.1	21	0	21
24	Because of the high ethical standard they implement in their profession and the superior knowledge of current scientific issues, engineers are uniquely positioned to minimize risk and take safety as the utmost importance	24	0.27	14	0.81	8	0.82	10
25	I feel like all the risks that they would minimize would be on a smaller scale	25	-1.56	35	-1.64	34	-1.63	35
26	I perceive risk as an element that can not be eliminated but can be minimized by taking the necessary measures and conducting a robust study prior implementing a project or making a decision	26	0	20	-0.62	27	-0.41	26
27	If decision making process was made to resemble more the systems engineering process of decision analysis maybe there are some things that politicians might miss that we could catch.	27	-0.59	26	-0.19	23	0	21
28	we as engineers have come out of an epistemology where as political science comes out of constructivism.	28	-0.86	29	-0.78	28	-0.82	30
29	Society would benefit from decisions based on sound factual scientific evidence	29	-0.43	23	0.84	7	0.82	10

30	I would say having decisions of higher quality, and broader than what politicians and the engineers that they hire, is one of the problems with the expert institutions that support decision making is that those people generally are nominated by the political power so they don't have the dependence	30	-0.129	32	-1.14	32	0.41	26
31	if you look at flint. Engineers who knew about all the problem there weren't taken seriously by the government there. If they were more engaged in that, possibly there would be taken action much sooner and there wouldn't be people drinking contaminated water for two years	31	-1.13	31	0.39	12	-0.41	26
32	I would think engineers are mostly involved in the implementation stage of decision making.	32	-0.43	23	-0.1	21	-1.63	35
33	I don't think engineers should be involved very early in decision making process; it should be planners. Planners have the concept and the view to build or construct something. And then the engineers come in to validate or de validate that planning	33	-0.59	26	-0.95	30	-1.22	33
34	the phases that come before are phases that concern the citizen that is, like identifying a problem or setting an agenda, and an engineer can be very helpful in those phases	34	-0.7	28	-1.11	31	-1.22	33
35	I think the engineers should participate but participate as a citizen and those things should actually be taken out of the hands of the politician, but also out of the hands of the engineers, they should be given to the people	35	0.16	17	-0.86	29	-0.41	26
36	in my opinion, is not about solving the problems, it's about determining as humans what problems should we care about and what are the things that should motivate us towards actions and that's where we mostly suffer	36	-1.03	30	-0.16	22	-0.82	30

Factor Matrix with an X Indicating a Defining Sort

Loadings

QSORT	1	2	3
1 Engineer	0.5478	0.4162	0.6727
2 Engineer	0.8621X	0.1928	0.2925
3 Engineer	0.7869X	0.3321	0.3794
4 Engineer	0.1766	0.9025X	0.2794
5 engineer	0.6727	0.5844	0.3630
6 Engineer	0.5525	0.7026X	0.3101
7 Engineer	0.6315	0.6887X	0.2514
8 Engineer	0.4406	0.6471	0.4884
9 Engineer	0.4214	0.3973	0.7787X
10 Engineer	0.2792	0.8689X	0.2809
% expl.Var.	33	38	20

Correlations Between Factor Scores

	1	2	3
1	1.0000	0.6408	0.7426
2	0.6408	1.0000	0.7272
3	0.7426	0.7272	1.0000

Factor Scores -- For Factor 1

No. Statement No. Z-SCORES

	Statements	Z score
1	My participation in public decision making is crucial significant and valuable, because as an engineer I have all the technical skills needed to make the right decision	1.989
2	I would participate in public policy for ego reasons just to think of oneself as being important.	-0.554
3	Positive reason for participation might be when the engineer perceives that the outcome of the decision as it stands currently is missing some insight that he is capable of providing	1.45
4	Engineers may choose to be involved in public policy because they are better positioned in introducing engineering approaches such as problem solving and risk assessment and mitigation - into the legislative, public policy processes and policy issues thus enhancing the viability of a denied policy.	1.55
5	I mean public policy affects you on a direct level so if you're one interested in it or two feel like you could make a difference then you should get involved	0.861
6	If engineers were involved in public policy issues we would have a technical perspective. I think most engineers are very objective and not based on opinion but based on knowledge	1.128
7	Engineers need to be placed in lawmaking as part of the process rather than a requirement.	0.164
8	The benefits of an engineer participating in public decision making is: • He/she can take the tangible benefits of science, engineering, and technology to people's lives, this is a fulfilling and gratifying benefit from an engineer perspective	0.431

9	The political process or decision making process is frustrating and requires time	-1.332
10	You have to make the effort to be heard and if you give up then you don't have the motivation to participate or someone shuts you out	0.431
11	Sometimes we choose not to participate because of cynicism, not believing it that it would help. The second reason would be believing that it may help but not agreeing with the outcome.	-1.722
12	The lack of understanding of what an engineer can and cannot do in a political process	0.861
13	The uncomfortable feeling of many of the Engineers to stand up and speak out on public policy issues during political process.	-0.431
14	Engineers are so driven on their own career life.	-0.697
15	The entire engineering mindset is to define a problem, identify alternatives, then implement the most beneficial solution	0.164
16	I reflect for myself, Am I qualified enough to voice my concern? Lack of education that comes to policy making. I have to ask two to three times of how can I bring this attention with comparing notes of the best way to bring my attention	1.353
17	To influence public decisions, some engineers should get in decision-making positions.	1.025
18	the opportunity to get involved in politics wasn't given to me, nobody has ever told me get involved	0.266
19	Engineers by both education and personality analyze problems and find solutions in a rational, systematic way	0
20	I might have some influence in some situations but not what I would call major decisions.	-1.456
21	I think other professions have more means of influence than engineers. For example, I guess lawyers or business executives would be more influential and in the US particularly, I think business executives and rich people in general are very influential because they can fund campaigns and use that funding as a means of influence	1.558
22	Engineers often have superior knowledge of current scientific issues as compared to career politicians which can be extremely useful when debating legislation regarding emission guidelines from automobiles, clean water, energy policies, and air pollution mandates	1.128
23	I would say as an external expert, I would say that's the main role that i can see, or as a member of government bodies who provide advice	0
24	Because of the high ethical standard they implement in their profession and the superior knowledge of current scientific issues, engineers are uniquely positioned to minimize risk and take safety as the utmost importance	0.266

25	I feel like all the risks that they would minimize would be on a smaller scale	-1.558
26	I perceive risk as an element that can not be eliminated but can be minimized by taking the necessary measures and conducting a robust study prior implementing a project or making a decision	0
27	If decision making process was made to resemble more the systems engineering process of decision analysis maybe there are some things that politicians might miss that we could catch.	-1.19
28	we as engineers have come out of an epistemology where as political science comes out of constructivism.	-0.861
29	Society would benefit from decisions based on sound factual scientific evidence	
30	I would say having decisions of higher quality, and broader than what politicians and the engineers that they hire, is one of the problems with the expert institutions that support decision making is that those people generally are nominated by the political power so they don't have the dependence	-1.292
31	if you look at flint. Engineers who knew about all the problem there weren't taken seriously by the government there. If they were more engaged in that, possibly there would be taken action much sooner and there wouldn't be people drinking contaminated water for two years	-1.128
32	I would think engineers are mostly involved in the implementation stage of decision making.	-0.431
33	I don't think engineers should be involved very early in decision making process; it should be planners. Planners have the concept and the view to build or construct something. And then the engineers come in to validate or de validate that planning	-0.595
34	the phases that come before are phases that concern the citizen that is, like identifying a problem or setting an agenda, and an engineer can be very helpful in those phases	-1.394
35	I think the engineers should participate but participate as a citizen and those things should actually be taken out of the hands of the politician, but also out of the hands of the engineers, they should be given to the people	0.164
36	in my opinion, is not about solving the problems, it's about determining as humans what problems should we care about and what are the things that should motivate us towards actions and that's where we mostly suffer	-1.025

Factor Scores -- For Factor 2

No. Statement No. Z-SCORES

	Statements	z score
1	My participation in public decision making is crucial significant and valuable, because as an engineer I have all the technical skills needed to make the right decision	1.726
2	I would participate in public policy for ego reasons just to think of oneself as bein important.	-1.486
3	Positive reason for participation might be when the engineer persceives that the outcome of the decision as it stands currently is missinh some inghight that he is capable of provididing	0.125
4	Engineers may choose to be involved in public policy because they are better positioned in introducing engineering approaches such as problem solving and risk assessment and mitigation - into the legislative, public policy processes and policy issues thus enhancing the viability of a denied policy.	0.896
5	I mean public policy affects you on a direct level so if you're one interested in it or two feel like you could make a difference then you should get involved	0.105
6	If engineers were involved in public policy issues we would have a technical perspective. I think most engineers are very objective and not based on opinion but based on knowledge	1.349
7	Engineers need to be placed in lawmaking as part of the process rather than a requirement.	-0.327
8	The benefits of an engineer participating in public decision making is: • He/she can take the tangible benefits of science, engineering, and technology to people's lives, this is a fulfilling and gratifying benefit from an engineer perspective	
9	The political process or decision making process is frustrating and requires time	1.433
10	You have to make the effort to be heard and if you give up then you don't have the motivation to participate or someone shuts you out	
11	Sometimes we choose not to participate because of cynicism, not believing it that it would help. The second reason would be believing that it may help but not agreeing with the outcome.	-1.669
12	The lack of understanding of what an engineer can and cannot do in a political process	1.208

13	The uncomfortable feeling of many of the Engineers to stand up and speak out on public policy issues during political process.	-0.327
14	Engineers are so driven on their own career life.	-0.105
15	The entire engineering mindset is to define a problem, identify alternatives, then implement the most beneficial solution	-0.603
16	I reflect for myself, Am I qualified enough to voice my concern? Lack of education that comes to policy making. I have to ask two to three times of how can I bring this attention with comparing notes of the best way to bring my attention	0.347
17	To influence public decisions, some engineers should get in decision-making positions.	0.776
18	the opportunity to get involved in politics wasn't given to me, nobody has ever told me get involved	0.725
19	Engineers by both education and personality analyze problems and find solutions in a rational, systematic way	0.381
20	I might have some influence in some situations but not what I would call major decisions.	-2.053
21	I think other professions have more means of influence than engineers. For example, I guess lawyers or business executives would be more influential and in the US particularly, I think business executives and rich people in general are very influential because they can fund campaigns and use that funding as a means of influence	-0.003
22	Engineers often have superior knowledge of current scientific issues as compared to career politicians which can be extremely useful when debating legislation regarding emission guidelines from automobiles, clean water, energy policies, and air pollution mandates	2.158
23	I would say as an external expert, I would say that's the main role that i can see, or as a member of government bodies who provide advice	-0.105
24	Because of the high ethical standard they implement in their profession and the superior knowledge of current scientific issues, engineers are uniquely positioned to minimize risk and take safety as the utmost importance	0.812
25	I feel like all the risks that they would minimize would be on a smaller scale	-1.642
26	I perceive risk as an element that can not be eliminated but can be minimized by taking the necessary measures and conducting a robust study prior implementing a project or making a decision	-0.618
27	If decision making process was made to resemble more the systems engineering process of decision analysis maybe there are some things that politicians might miss that we could catch.	-0.189
28	we as engineers have come out of an epistemology where as political science comes out of constructivism.	-0.779

29	Society would benefit from decisions based on sound factual scientific evidence	0.843
30	I would say having decisions of higher quality, and broader than what politicians and the engineers that they hire, is one of the problems with the expert institutions that support decision making is that those people generally are nominated by the political power so they don't have the dependence	-1.139
31	if you look at flint. Engineers who knew about all the problem there weren't taken seriously by the government there. If they were more engaged in that, possibly there would be taken action much sooner and there wouldn't be people drinking contaminated water for two years	0.39
32	I would think engineers are mostly involved in the implementation stage of decision making.	-0.105
33	I don't think engineers should be involved very early in decision making process; it should be planners. Planners have the concept and the view to build or construct something. And then the engineers come in to validate or de validate that planning	-0.947
34	the phases that come before are phases that concern the citizen that is, like identifying a problem or setting an agenda, and an engineer can be very helpful in those phases	-1.106
35	I think the engineers should participate but participate as a citizen and those things should actually be taken out of the hands of the politician, but also out of the hands of the engineers, they should be given to the people	-0.863
36	in my opinion, is not about solving the problems, it's about determining as humans what problems should we care about and what are the things that should motivate us towards actions and that's where we mostly suffer	-0.158

Factor Scores -- For Factor 3

No. Statement No. Z-SCORES

	Statements	z score
1	My participation in public decision making is crucial significant and valuable, because as an engineer I have all the technical skills needed to make the right decision	2.041
2	I would participate in public policy for ego reasons just to think of oneself as bein important.	-2.041

3	Positive reason for participation might be when the engineer persceives that the outcome of the decision as it stands currently is missinh some inghight that he is capable of provididing	1.225
4	Engineers may choose to be involved in public policy because they are better positioned in introducing engineering approaches such as problem solving and risk assessment and mitigation - into the legislative, public policy processes and policy issues thus enhancing the viability of a denied policy.	1.633
5	I mean public policy affects you on a direct level so if you're one interested in it or two feel like you could make a difference then you should get involved	0.816
6	If engineers were involved in public policy issues we would have a technical perspective. I think most engineers are very objective and not based on opinion but based on knowledge	1.225
7	Engineers need to be placed in lawmaking as part of the process rather than a requirement.	0
8	The benefits of an engineer participating in public decision making is: • He/she can take the tangible benefits of science, engineering, and technology to people's lives, this is a fulfilling and gratifying benefit from an engineer perspective	0.408
9	The political process or decision-making process is frustrating and requires time	0.408
10	You have to make the effort to be heard and if you give up then you don't have the motivation to participate or someone shuts you out	0.408
11	Sometimes we choose not to participate because of cynicism, not believing it that it would help. The second reason would be believing that it may help but not agreeing with the outcome.	-0.408
12	The lack of understanding of what an engineer can and cannot do in a political process	0.816
13	The uncomfortable feeling of many of the Engineers to stand up and speak out on public policy issues during political process.	-0.816
14	Engineers are so driven on their own career life.	-0.816
15	The entire engineering mindset is to define a problem, identify alternatives, then implement the most beneficial solution	0
16	I reflect for myself, Am I qualified enough to voice my concern? Lack of education that comes to policy making. I have to ask two to three times of how can I bring this attention with comparing notes of the best way to bring my attention	0.408
17	To influence public decisions, some engineers should get in decision-making positions.	0.408

18	the opportunity to get involved in politics wasn't given to me, nobody has ever told me get involved	
19	Engineers by both education and personality analyze problems and find solutions in a rational, systematic way	0
20	I might have some influence in some situations but not what I would call major decisions.	-1.225
21	I think other professions have more means of influence than engineers. For example, I guess lawyers or business executives would be more influential and in the US particularly, I think business executives and rich people in general are very influential because they can fund campaigns and use that funding as a means of influence	1.225
22	Engineers often have superior knowledge of current scientific issues as compared to career politicians which can be extremely useful when debating legislation regarding emission guidelines from automobiles, clean water, energy policies, and air pollution mandates	0
23	I would say as an external expert, I would say that's the main role that i can see, or as a member of government bodies who provide advice	0
24	Because of the high ethical standard they implement in their profession and the superior knowledge of current scientific issues, engineers are uniquely positioned to minimize risk and take safety as the utmost importance	0.816
25	I feel like all the risks that they would minimize would be on a smaller scale	-1.633
26	I perceive risk as an element that can not be eliminated but can be minimized by taking the necessary measures and conducting a robust study prior implementing a project or making a decision	-0.408
27	If decision making process was made to resemble more the systems engineering process of decision analysis maybe there are some things that politicians might miss that we could catch.	0
28	we as engineers have come out of an epistemology where as political science comes out of constructivism.	
29	Society would benefit from decisions based on sound factual scientific evidence	0.816
30	I would say having decisions of higher quality, and broader than what politicians and the engineers that they hire, is one of the problems with the expert institutions that support decision making is that those people generally are nominated by the political power so they don't have the dependence	-0.408

31	if you look at flint. Engineers who knew about all the problem there weren't taken seriously by the government there. If they were more engaged in that, possibly there would be taken action much sooner and there wouldn't be people drinking contaminated water for two years	-0.408
32	I would think engineers are mostly involved in the implementation stage of decision making.	-1.6333
33	I don't think engineers should be involved very early in decision making process; it should be planners. Planners have the concept and the view to build or construct something. And then the engineers come in to validate or de validate that planning	-1.225
34	the phases that come before are phases that concern the citizen that is, like identifying a problem or setting an agenda, and an engineer can be very helpful in those phases	-1.225
35	I think the engineers should participate but participate as a citizen and those things should actually be taken out of the hands of the politician, but also out of the hands of the engineers, they should be given to the people	-0.408
36	in my opinion, is not about solving the problems, it's about determining as humans what problems should we care about and what are the things that should motivate us towards actions and that's where we mostly suffer	-0.816

Descending Array of Differences Between Factors 1 and 2

No. Statement

No.	Type1	Type2	Difference
21	1.558	-0.003	1.561
3	1.456	0.125	1.331
35	0.164	-0.863	1.027
16	1.353	0.347	1.006
2	-0.554	-1.486	0.932
15	0.164	-0.603	0.767
5	0.861	0.105	0.756
4	1.558	0.896	0.663
26	-0.000	-0.618	0.618
20	-1.456	-2.053	0.597
7	0.164	-0.327	0.491
34	-0.697	-1.106	0.409
33	-0.595	-0.947	0.353
1	1.989	1.726	0.263
17	1.025	0.776	0.249
10	0.431	0.243	0.188
23	-0.000	-0.105	0.105

25	-1.558	-1.642	0.084
11	-1.722	-1.669	-0.053
28	-0.861	-0.779	-0.082
13	-0.431	-0.327	-0.104
30	-1.292	-1.139	-0.153
6	1.128	1.349	-0.221
8	0.431	0.707	-0.276
32	-0.431	-0.105	-0.326
12	0.861	1.208	-0.347
19	-0.000	0.381	-0.381
27	-0.595	-0.189	-0.406
18	0.266	0.725	-0.459
24	0.266	0.812	-0.546
14	-0.697	-0.105	-0.592
36	-1.025	-0.158	-0.867
22	1.128	2.158	-1.030
29	-0.431	0.843	-1.273
31	-1.128	0.390	-1.518
9	-1.332	1.433	-2.765

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Descending Array of Differences Between Factors 1 and 3

No. Statement

No. Type1 Type 3 Difference

2	-0.554	-2.041	1.487
32	-0.431	-1.633	1.202
22	1.128	0.000	1.128
16	1.353	0.408	0.945
33	-0.595	-1.225	0.630
17	1.025	0.408	0.617
35	0.164	-0.408	0.572
34	-0.697	-1.225	0.528
26	-0.000	-0.408	0.408
13	-0.431	-0.816	0.386
21	1.558	1.225	0.334
3	1.456	1.225	0.231
15	0.164	0.000	0.164
7	0.164	0.000	0.164
14	-0.697	-0.816	0.119
25	-1.558	-1.633	0.075
12	0.861	0.816	0.045

5	0.861	0.816	0.045
8	0.431	0.408	0.022
10	0.431	0.408	0.022
23	-0.000	0.000	-0.000
19	-0.000	0.000	-0.000
28	-0.861	-0.816	-0.045
1	1.989	2.041	-0.052
4	1.558	1.633	-0.075
6	1.128	1.225	-0.097
36	-1.025	-0.816	-0.209
20	-1.456	-1.225	-0.231
24	0.266	0.816	-0.550
27	-0.595	0.000	-0.595
3	-1.128	-0.408	-0.719
30	-1.292	-0.408	-0.884
29	-0.431	0.816	-1.247
11	-1.722	-0.408	-1.314
18	0.266	1.633	-1.366
9	-1.332	0.408	-1.741

Descending Array of Differences Between Factors 2 and 3

No. Statement No. Type 2 Type 3 Difference

22	2.158	0.000	2.158
32	-0.105	-1.633	1.528
9	1.433	0.408	1.025
31	0.390	-0.408	0.798
14	-0.105	-0.816	0.712
36	-0.158	-0.816	0.658
2	-1.486	-2.041	0.555
13	-0.327	-0.816	0.490
12	1.208	0.816	0.391
19	0.381	0.000	0.381
17	0.776	0.408	0.368
8	0.707	0.408	0.299
33	-0.947	-1.225	0.277
6	1.349	1.225	0.124
34	-1.106	-1.225	0.119
28	-0.779	-0.816	0.038
29	0.843	0.816	0.026
24	0.812	0.816	-0.004
25	-1.642	-1.633	-0.009
16	0.347	0.408	-0.061
23	-0.105	0.000	-0.105
10	0.243	0.408	-0.166

27	-0.189	0.000	-0.189
26	-0.618	-0.408	-0.209
1	1.726	2.041	-0.315
7	-0.327	0.000	-0.327
35	-0.863	-0.408	-0.455
15	-0.603	0.000	-0.603
5	0.105	0.816	-0.712
30	-1.139	-0.408	-0.731
4	0.896	1.633	-0.737
20	-2.053	-1.225	-0.828
18	0.725	1.633	-0.908
3	0.125	1.225	-1.099
21	-0.003	1.225	-1.227
11	-1.669	-0.408	-1.261

Exact Factor Scores (á la SPSS) in Z-Score and T-Score units

Factors

No.	1		2		3	
1	1.37	64	1.12	61	0.91	59
2	0.19	52	-1.09	39	-2.26	27
3	1.70	67	-0.64	44	1.31	63
4	0.75	58	0.05	50	1.40	64
5	0.92	59	-0.49	45	0.68	57
6	0.84	58	1.07	61	0.50	55
7	0.40	54	-0.47	45	0.05	50
8	0.07	51	0.58	56	0.38	54
9	-1.77	32	2.45	75	0.13	51
10	0.42	54	0.08	51	0.24	52
11	-1.65	34	-1.61	34	1.26	63
12	0.80	58	1.15	61	-0.05	49
13	0.22	52	0.11	51	-1.32	37
14	-0.68	43	0.37	54	-0.84	42
15	0.62	56	-0.82	42	0.36	54
16	1.80	68	-0.15	49	-0.56	44
17	1.23	62	0.44	54	-0.75	43
18	-0.31	47	0.44	54	1.59	66
19	-0.38	46	0.54	55	0.43	54
20	-1.03	40	-1.84	32	0.05	50
21	1.16	62	-1.24	38	1.88	69
22	1.02	60	2.33	73	-0.80	42
23	-0.29	47	-0.22	48	0.37	54
24	-0.21	48	0.89	59	0.33	53
25	-1.03	40	-1.19	38	-0.97	40

26	0.25	53	-0.81	42	-0.09	49
27	-0.47	45	0.13	51	-0.04	50
28	-0.94	41	-0.50	45	-0.38	46
29	-1.44	36	0.95	60	0.92	59
30	-0.96	40	-0.84	42	0.18	52
31	-1.96	30	0.83	58	0.17	52
32	0.07	51	0.59	56	-2.22	28
33	0.62	56	-0.47	45	-2.22	28
34	-0.27	47	-0.97	40	-0.67	43
35	0.40	54	-1.13	39	-0.05	50
36	-1.46	35	0.36	54	0.10	51

Factor Q-Sort Values for Each Statement

Factor Arrays

No. Statement	No. 1	2	3
1	5	4	5
2	-1	-3	-5
3	3	0	3
4	4	3	4
5	2	0	2
6	2	3	3
7	0	-1	0
8	1	1	1
9	-3	4	1
10	1	1	1
11	-5	-4	-1
12	2	3	2
13	-1	-1	-2
14	-2	0	-2
15	0	-1	0
16	3	1	1
17	2	2	1
18	1	2	4
19	0	1	0
20	-4	-5	-3
21	4	0	3
22	2	5	0
23	0	0	0
24	1	2	2
25	-4	-4	-4
26	0	-2	-1
27	-1	-1	0
28	-2	-2	-2

29	-1	2	2
30	-3	-3	-1
31	-3	1	-1
32	-1	0	-4
33	-1	-2	-3
34	-2	-3	-3
35	0	-2	-1
36	-2	-1	-2

Variance = 5.833 St. Dev. = 2.415

Factor Q-Sort Values for Statements sorted by Consensus vs. Disagreement (Variance across Factor Z-Scores)

Factor Arrays

No. Statement No. 1 2 3

Factor Characteristics

	Factors		
	1	2	3
No. of Defining Variables	2	4	1
Average Rel. Coef.	0.800	0.800	0.800
Composite Reliability	0.889	0.941	0.800
S.E. of Factor Z-Scores	0.333	0.243	0.447

Standard Errors for Differences in Factor Z-Scores

(Diagonal Entries Are S.E. Within Factors)

Factors	1	2	3
1	0.471	0.412	0.558
2	0.412	0.343	0.509
3	0.558	0.509	0.632

Distinguishing Statements for Factor 1

(P < .05 ; Asterisk (*) Indicates Significance at P < .01)

Both the Factor Q-Sort Value (Q-SV) and the Z-Score (Z-SCR) are Shown.

	Factors 1		2		3	
No	Q-SV	Z-SCR	Q-SV	Z-SCR	Q-SV	Z-SCR
22	2	1.13	5	2.16	0	0.00
29	-1	-0.43	2	0.84	2	0.82
2	-1	-0.55	-3	-1.49	-5	-2.04
9	-3	-1.33*	4	1.43	1	0.41

Distinguishing Statements for Factor 2

(P < .05 ; Asterisk (*) Indicates Significance at P < .01)

Both the Factor Q-Sort Value (Q-SV) and the Z-Score (Z-SCR) are Shown.

	Factors 1		2		3	
No	Q-SV	Z-SCR	Q-SV	Z-SCR	Q-SV	Z-SCR
22	2	1.13	5	2.16	0	0.00
9	-3	-1.33	4	1.43	1	0.41
3	3	1.46	0	0.13	3	1.22
21	4	1.56	0	-0.00	3	1.22

Distinguishing Statements for Factor 3

(P < .05 ; Asterisk (*) Indicates Significance at P < .01)

Both the Factor Q-Sort Value (Q-SV) and the Z-Score (Z-SCR) are Shown.

	Factors 1		Factors 2		Factors 3	
No	Q-SV	Z-SCR	Q-SV	Z-SCR	Q-SV	Z-SCR
9	-3	-1.33	4	1.43	1	0.41
22	2	1.13	5	2.16	0	0.00
11	-5	-1.72	-4	-1.67	-1	-0.41
32	-1	-0.43	0	-0.10	-4	-1.63

Consensus Statements -- Those That Do Not Distinguish Between ANY Pair of Factors.

All Listed Statements are Non-Significant at P>.01, and Those Flagged With an * are also Non-Significant at P>.05.

	Factors 1		Factors 2		Factors 3	
No.	Q-SV	Z-SCR	Q-SV	Z-SCR	Q-SV	Z-SCR
1*	5	1.99	4	1.73	5	2.04
4*	4	1.56	3	0.90	4	1.63
5*	2	0.86	0	0.10	2	0.82
6*	2	1.13	3	1.35	3	1.22
7*	0	0.16	-1	-0.33	0	0.00
8*	1	0.43	1	0.71	1	0.41
10*	1	0.43	1	0.24	1	0.41
11	-5	-1.72	-4	-1.67	-1	-0.41
12*	2	0.86	3	1.21	2	0.82
13*	-1	-0.43	-1	-0.33	-2	-0.82
14*	-2	-0.70	0	-0.10	-2	-0.82
15*	0	0.16	-1	-0.60	0	0.00
16	3	1.35	1	0.35	1	0.41
17*	2	1.03	2	0.78	1	0.41
18	1	0.27	2	0.73	4	1.63
19*	0	-0.00	1	0.38	0	0.00
20*	-4	-1.46	-5	-2.05	-3	-1.22
23*	0	-0.00	0	-0.10	0	0.00
24*	1	0.27	2	0.81	2	0.82

25*	-4	-1.56	-4	-1.64	-4	-1.63
26*	0	-0.00	-2	-0.62	-1	-0.41
27*	-1	-0.59	-1	-0.19	0	0.00
28*	-2	-0.86	-2	-0.78	-2	-0.82
30*	-3	-1.29	-3	-1.14	-1	-0.41
33*	-1	-0.59	-2	-0.95	-3	-1.22
34*	-2	-0.70	-3	-1.11	-3	-1.22
35	0	0.16	-2	-0.86	-1	-0.41
36	-2	-1.03	-1	-0.16	-2	-0.82

QANALYZE was completed at 23:47:

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EDUCATION

2014-2018 Old Dominion University, School of Engineering Management, USA
Doctor of Philosophy In Engineering Management and Systems Engineering
-Diversity Award delivered by the Old Dominion University in recognition of students' engagement cultural diversity.

2011-2012 Old Dominion University, School of Economics, USA
Masters in Managerial Economics
-Leadership Award delivered by the Old Dominion University in recognition of students' engagement in extracurricular activities

2007-2010 Mohammed Fifth University, Souissi - Rabat, Morocco
Master's in Economics and Law
-Moroccan Ministry of Higher Education Scholarship & Prize of Excellence awarded on the basis of academic excellence

2004-2007 Mohammed Fifth University, Souissi - Rabat, Morocco
Bachelor's in Economics and Law

ACADEMIC EXPERIENCE

Jan. 2017-Present Adjunct Faculty – Old Dominion University, School of Engineering Management, USA

Responsibilities:
Develop Engineering Management courses (Project Management/ Engineering Ethics)
Assess students' records and working with 'at-risk students'
Motivate students to achieve completion of their projects and assignments.
Highlight fundamental speaking, listening, reading and writing skills
Award:
Shining star award delivered by the Old Dominion University for helping student succeed academically

March2014 Jan 2017 Instructional Designer GA – Old Dominion University, Learning and

Teaching Department, USA

Responsibilities:
- Revise and rewrite content to shape it for learning needs
- Structure content and activities for student learning
- Create media to support learning
- Develop assessments and strategies of needs
- Adapt instructional materials
- Use Camtasia Studio to create video presentations
- Formulate new strategies for the effectiveness and the efficiency of materials

Jan.2013 Jan. 2014 — Adjunct Faculty – Tidewater Community College, School of Economics, USA

Responsibilities:
Develop economics courses.
Provide academic support and assistance to students in group and individually
Arrange different class room events to increase students' interest in Economics.
Motivate students to achieve completion of their projects and assignments.
Assess students based on their performance in the periodic tests and provide individual feedback to them

WORK EXPERIENCE

March. 2010-Jan. 2011 — Project Manager - SABA & CO Group -Casablanca Morocco

Responsibilities:
Identify the required resources of projects
Set project goals
Provide necessary guidance for the project team
Prepare project management program

Feb 2009.- March 2010 — Project Consultant - NIELSEN- Casablanca Morocco

Responsibilities:
Analyse data and provide reports
Ensure the completion of tasks
Ensure that projects meet the requirements (scope, budget, schedule)
Communicate with clients

Sept. 2005/- Sept. 2006 Purchasing Agent – B Junior Construction- Kenitra Morocco

Responsibilities:
Evaluate suppliers
Analyse proposals and prepare orders
Monitor merchandise's shipment

CERTIFICATES

Divers-ability training Certificate/ ODU- Norfolk VA

Diversity Institute Certificate/ODU- Norfolk VA

Leadership Certificate /ODU- Norfolk VA

Preparing Future Faculty Certificate / ODU-Norfolk VA .

KEY SKILLS

Languages: Fluent in English, Arabic, and French

Computing and software: Html, Matlab, E views, Microsoft office, Minitab, Net log, Camtasia, Fireworks Adobe, experience with multiple features in Blackboard.

PUBLICATIONS AND CONFERENCE PRESENTATIONS

- **Bouazzaoui**, S, & Daniels, C.B (2018, June). Using a grounded theory to determine the motivational factors of Engineers' participation in public policy. ASEE annual Conference and exposition. Salt Lake city, Utah.
- Toba, A. L., Seck, M., Keskin, O., **Bouazzaoui**, S., & Ngatang, I. (2018, April) Tool Development for electricity system network Management. SpringSim Conference, Baltimore, Maryland, USA
- Taylor, A. K., & **Bouazzaoui**, S. (2018, July). Moving Forward with Autonomous Systems: Ethical Dilemmas. In International Conference on Applied Human Factors and Ergonomics.
- **Bouazzaoui**, S, Daniels, C.B, Poyraz, O.I, Tobba, A.L (2018, April) IoT-related DDoS Ethical Issues: A System of Systems Approach. International conference on Cyber Warfare and Security
- Tobba, A.L, Seck, M., Amissah, M., **Bouazzaoui**, S (2017, December). An Approach DEVS for DEVS based modelling for Electric Power Systems. WinterSim Conference, LasVegas, Nevada, USA
- Amissah, M., Tobba, A.L, **Bouazzaoui**, S, Shahiari, N (2017, June) Building Executable Discrete Event Models with SysML and Alf. 12th System of Systems Engineering. Waikoloa, Hawai, USA

- Shahiari, N., Gheorghe, A., Amissah, M, **Bouazzaoui**, S. (2017, April).Agent-based Modeling of Natural Gas Systems. Poster Session presented at the SpringSim Conference, Virginia Beach, VA, USA
- **Bouazzaoui**, S. Witherow, M. Castelle, K.M (2016, October) Ethics and Robotics. The 2016 International Annual Conference of the American Society for Engineering Management, Concord, NorthCarolina, USA
- **Bouazzaoui**, S (2010). Evaluation de l'aspect juridique du projet sur l'amélioration du climat des affairs au Maroc: cas des entreprises en difficultés. Mohamed V - souissi –faculte des sciences juridiques economiques et sociales rabat souissi Retrieved from ProQuest Dissertations and Theses