Modes of Humanities and Social Thought in Entry Level Civil Engineering

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Dedication

This dissertation is dedicated to the memory of my parents, Theodore and Cecilia Toussaint, who first taught me the value of education. Although they were my inspiration to pursue my doctoral degree, they were unable to see my graduation.

Abstract

Like the rest of society, civil engineering has called for a balance among the interlinkages of economics, society, and the environment. Civil engineering governing bodies look to the humanities and social sciences as ingredients in the formula for such a balance in civil engineering education. However, the governing bodies appear to have left the strategy for implementation to educators. Inevitably, if we are to implement humanities and social sciences into the civil engineering curriculum, we need to answer the questions: what humanities and social sciences? And to what extent?

This dissertation aimed to contribute to these answers. The objective of this study was to identify the modes of humanities and social thought in entry-level civil engineering. The study used a conceptual framework, which combines Vygotsky's concept of the zone of proximal development, the concept of scaffolding and Jean Lave and Etienne Wenger concepts of community of practice and peripheral participation. This combination provided a framework by which I could investigate the humanities and social sciences in entry-level civil engineering practice and by so doing can inform engineering educators about undergraduate civil engineering curriculum.

A grounded theory methodology as used to discover a phenomenon from which assertions were made about humanities and social sciences in entry-level civil engineering. Seven concepts emerged from the data. Through the interaction, interconnections of these seven concepts emerged the phenomenon, 'Sustainable Civil Infrastructure Projects'. Sustainable Civil Infrastructure Projects take steps to optimize sustainability through the conscious application of sustainable management, effective communication, rules and ethics. These discipline branches of social science and humanities are foundational to sustainable civil engineering practice. However, navigating the social characteristics of sustainable civil engineering practice require more nuance. It requires the knowledge and application of social sciences and humanities that are not typically associated with engineering but are blended into sustainable civil engineering practice. The social sciences and humanities are interwoven into sustainable practice but connected in specific ways. This dissertation offered fourteen assertions to summarize the findings concerning the modes of humanities and social thought that are salient to entry-level civil engineers.

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CHAPTER I: INTRODUCTION

Background

Can you imagine a world without civil engineering? This might be a more difficult question to answer than you think, because many people do not actually know the extent to which we rely on civil engineering for our world to function. It is only by exploring the work that civil engineers do are we able to understand the importance of their profession and its impact on society.

The discipline of civil engineering is one of the oldest in the world, arguably as old as civilization itself. The first engineers were those who developed the lever, the pulley and the inclined plane. Ancient civil engineering creations include such work as the Egyptian Pyramids and the Roman aqueducts. Today, civil engineering covers a broad range of disciplines all devoted to keeping modern civilization functioning. Civil engineers work to maintain and improve the civil infrastructure systems of our modern cities such as roads, airports and transportation networks. This is applied in the construction and management of Roads – Bridges – Rail Roads – Aqueducts – tunnels – Canals – River Navigation – Airports – Docks, and Storehouses for the convenience of internal intercourse and exchange; in the construction of Ports – Harbors – Moles – Breakwaters – pipelines and Lighthouses, for navigation by artificial Power for the purposes of commerce; the design and construction of water supplies, municipal sewer systems, wastewater treatment plants and buildings to protect us from natural hazards and provide health care and agriculture through water resource development and distribution.

However, the great benefits of civil engineering come with great perils. Civil engineering projects have had adverse effects on the natural and social environment. Indigenous and minority people have been disproportionately affected by civil construction projects. So skewed were the effects that the Environmental Justice Movement emerged in the 1980s in reaction to discriminatory environmental practices, which negatively affected socioeconomically disadvantage communities and communities of color.

Consequently, one of the defining challenges for civil engineers in the twenty-first century is to respond to a problem in terms of human and social impact. The civil engineering community will have a key role to play in the mitigation of and adaptation to environmental and social changes. The role of civil engineers starts with impact assessment, the social relevance and responsibility of their engineering decisions.

Contemporary engineers must be aware of the cultural and environmental impacts of their professional activity, and cognizant of the contribution engineering design can make to societies and quality of life (Vere, Johnson and Thong, 2009). To achieve this, engineering scholars recommend that the engineering profession must evolve from the role of technical service provider, to a profession that is guided by its, “understanding of the human, environmental, societal and cultural challenges and the consequences of professional activity” (Vere, Johnson and Thong, 2009, p. 1).

Research Rationale

This study took the first step towards fully comprehending the definition of a 21st century civil engineer by evaluating modes of humanities and social thought in entry-level civil engineering practice. This, I expect, will inform undergraduate civil engineering education. The discourse on engineering skill development infers that the 21st century brings new challenges and changes to civil engineering education and practice. “The environment for civil engineering practice is changing dramatically and irreversibly, impelled by the shift from defense to commercial competition as a major driver for engineering employment” (Prados, 1998, p.1). The impact of exploding information technology, as well as computer aided engineering such as building information modeling, the introduction of nanotechnology, the globalization of both manufacturing and service delivery, the imperatives of environmental protection, sustainable development, and U.S. infrastructure deterioration are all challenges to be addressed (Blumenthal and Grothus, 2008; Galloway, 2003; Russell, Hanna, Bank and Shapira, 2007; Soibelman, Sacks, Akinci, Dikemen, et al., 2011). The 21st Century civil engineering profession now requires competence beyond technical skills (Grandin and Hirleman, 2009). According to Apelian (2007), the technical skills, the people skills, and the innovation requirements of the future civil engineers can be summarized with only modest exaggeration as follows: Knows everything; Can do anything; Works with anybody anywhere; and imagines and can make the imagination a reality.

Thus, the American Society of Civil Engineers (ASCE), Accreditation Board for Engineering and Technology (ABET) and National Council of Examiners for Engineering and Surveying (NCEES) mutually call for the inclusion of social science and humanities into the new civil engineering curricula. It appears that these governing bodies are requiring civil engineers to be omni-competent, and especially globally competent. This study initiated a strategy for empirical analysis of civil engineering skill development by shedding light on the role the humanities and social sciences play in preparing civil engineers to meet future challenges.

Statement of the Problem

Though there are calls for progressive civil engineering education reform, there is not a well-defined strategy for doing so. At the undergraduate school level, engineering education in the US focuses on the physical sciences, design, and making students technical experts (Prado, 1998). However, future engineering practice also demands skills in negotiation, finance, policy, and politics (Prado, 1998). Civil engineering governing bodies have advocated for changes to civil engineering education and practice that now includes a greater focus on social sciences and humanities. However, there is a lack of unified guidance for acquiring the specified set of skills or for integrating social science and humanities into the civil engineering curricula.

Purpose of the study

According to the discourse on engineering education, the two most prominent challenges facing Engineering Education are in research and in the scholarship of teaching and learning (Borrego, Streveler, Miller and Smith, 2008; Radcliffe and Jolly, 2003; Wankat, Felder, Smith and Oreovicz, 2002). This dissertation will focus on the later as it relates to preparing civil engineers for professional practice. Both the public sector and private industry want entry-level civil engineers to be technically skillful, however, they also want these engineers to be competent in a variety of professional practices. The engineering industry want civil engineers to be technically sound, socially adept, and verse in the subjects of economics and politics so that they can work as part of teams, effectively manage projects, good communicators, and understand the economic, social and political context of their professional activities. Due to these professional expectations, engineering education is becoming more demanding. In the article, *Redesigning Engineering Curricula for the 21st Century*, the author espouses the idea that:

> "Engineers handle an ever-growing body of engineering knowledge; many programs are crammed with technical information and leave little room for students to develop professional practices that enable them to become skillful communicators, ethical decision makers, team leaders, creative thinkers, and problem solvers. However, professional practices are essential, even critical, since engineers regularly interact with people in local, national, and international communities and create technical solutions that address complex social and environmental issues. The time crunch in over-packed undergraduate programs challenges us to redefine high-quality engineering education. The time crunch is complicated in four

additional ways: a pedagogy that often emphasizes recall rather than contextualized learning with higher-order thinking and problem solving, a faculty that is unsure of effective ways to teach and assess professional practices, assessment that is overly dependent on indirect measures, and a lack of sufficiently detailed and sophisticated assessment research that informs curriculum revision." (Redesigning Engineering Curricula for the 21st Century, 2012" (p.1).

However, the assertion that there is a lack of synergy between civil engineering education and future civil engineering professional skills does not advance a way of incorporating the humanities and social sciences that is alluded. The purpose of this study was to introduce empirical analysis into the call for renewed civil engineering education and practice and for social science and humanities in civil engineering education. Specifically, this study examined the modes of humanities and social thought in entry-level civil engineering practice, to help better define the broad issues related to non-technical skills necessitating a change in undergraduate civil engineering education.

Principal Research Question

To be accredited, instructional programs in civil engineering must now set forth learning objectives that involve both technical and non-technical, assessment measures to determine how well the objectives are achieved and plans for taking remedial action to address shortcomings revealed by the assessment (Radcliffe and Jolly, 2003). Since there appear to be a lack of unified guidance on the extent to which social sciences and humanities should be included in the undergraduate civil engineering curricula, the question to be answered in this study was – What modes of humanities and social thought are salient for entry-level civil engineers?

Potential Significance of the Study

This study attempted to contribute to the answer to the question of integrating social science and humanities into civil engineering education. This research hoped to define the social science and humanities issues that affect civil engineering practice. By understanding these issues, researchers and policymakers can design more effective and integrated programs. The findings to this study may not be definitive. However, it may provide more insight and add a new perspective to the discourse.

Definition of terms

In this section, the definitions of key terms used in this proposal will be discussed. Many of the terms used are technical in nature; however, a clear and comprehensive understanding of their definitions is pertinent to the discussions at hand.

Building information modeling

Howell and Batcheler (2004), describes Building Information Modeling (BIM) as:

> “The latest generation of OOCAD systems in which all of the intelligent building objects that combine to make up a building design can coexist in a single ‘project database’ or ‘virtual building’ that captures everything known about the building. A building information model (in theory)

provides a single, logical, consistent source for all information associated with the building" (p. 1).

By OOCAD, they are referring to Object-Oriented Computer Aided Design systems.

Civil engineering

The American Heritage Dictionary, the Institution of Civil Engineers and the American Society of Civil Engineers all define civil engineering as a field of engineering sciences, related to design**,** construction and maintenance of buildings, dams, bridges, tunnels, highways, ports, railways, airports, waterways and other structures by the use of physical laws, mathematical equations and theories of mechanics.

Civil infrastructure system

These are the infrastructure systems that are planned, designed, constructed and maintained by civil engineers. Those again would include buildings, dams, bridges, tunnels, highways, ports, railways, airports, waterways, water treatment facilities and other structures.

Computer aided engineering

Computer aided engineering (CAE) is the usage of computers to aid in engineering tasks. The three most common systems of CAE used in civil engineering are Computer-aided design (CAD), computer-aided analysis (CAA) and computer-aided planning (CAP). Computer aided design is the use of computers and related software for modeling physical systems. This allows the interactive and automatic analysis of design variants and the expression of designs in a form suitable for construction, for example, plans and specifications.

Computer-aided analysis includes diverse programs for specialized analyses. Some examples of analyses that are performed within civil engineering with the use of CAA include:

- Earthquake analysis
- Failure analysis
- Offshore platforms design and analysis
- Pavement design
- Thermal and fluid analysis
- Kinematics and dynamic analysis
- Stress and dynamics analysis

Computer-aided planning has become an integral part of civil engineering practice. Engineering managers used these programs to plan every detail of their projects.

Global competence

There is a lack of consensual definition of global competence (Hunter, White and Godbey, 2006). However, according to the article, *What Does it mean to be Globally Competent?*, Hunter et al. (2006) defines global competence as, “Having an open mind while actively seeking to understand cultural norms and expectations of others, leveraging this gained knowledge to interact, communicate and work effectively outside one’s environment,” (p. 6). Lohmann, Rollins, and Hoey (2005) define the term as the ability to work knowledgeably and live comfortably in a transnational engineering environment and global society. For purposes of this dissertation, we shall define global competence as being duly prepared for the global workplace and our multicultural society.

Globalization

Globalization is not a new phenomenon; it has been taking place for centuries. Through those centuries, three major phases have made the world a more homogenous place: European explorations of the late thirteenth and fourteenth centuries; the migration of African slaves; and the influx of Europeans and Asians to America in the nineteenth and early twentieth century. Today globalization is seen as an economic phenomenon that brings the producers and consumers of different continents and regions into functional relationships through the free exchange of goods, services and capital (Kazmi, 2005; Pan, 2005). Globalization is a phenomenon that comprises multiple and drastic change in all aspects of social life, especially in economics and culture (Stromquist and Monkman, 2000). It conceptualizes a fundamental process of change that integrates the global economy through trade, financial flows, exchange of technology and information, and movement of people throughout the world (Stromquist and Monkman, 2000). According to Potier (2004), globalization focuses on global economic integration through processes related to free market. Sheenhan (2010), defines globalization as "a process of integration—on a worldwide scale—of markets, production, and distribution through the free flow of capital and labor, which will inevitably lead to the world becoming a global village" (p. 1).

Information technology

Information Technology (IT) has been defined in different ways. For this study, our definition is that it includes the set of technologies that rely on computers and digital data sets (Grigg, Criswell, Fontane and Siller, 2005). This includes technologies used to plan and design civil engineering systems (such as Computer-Aided Design or project management software) and those needed to control system components (such as a traffic signal) and entire systems (such as a multipurpose dam) (Grigg et al, 2005).

Nanotechnology

Nanotechnology is the use of very small particles of material either by themselves or by their manipulation to create new large-scale materials (Mann, 2006). The nanotechnologies can be defined as the design, characterization, production and application of structures, devices and systems by controlling shape and size at the nanoscale (10^{-9} m) (Uskokovic, 2010).

Sustainability

Sustainability is about finding the right balance between economic wellbeing, the benefit of society and concern for the environment and its resources, together with a notion of intergenerational equity (Jowitt, 2004). The American Society of Civil Engineers defines sustainability as a set of environmental, economic and social conditions in which all of society has the capacity and opportunity to maintain and improve its quality of life indefinitely without degrading the quantity, quality or availability of natural, economic and social resources.

CHAPTER II: LITERATURE REVIEW

Introduction

The purpose of this literature review is to present the relevant research arguments that inform my study. The articles reviewed provide insight into the relationship between engineering education and engineering practice, the methods used to measure the relationships, and the realities of conducting this study. The literature review focuses on two questions that I regard to be the prerequisites of this proposed dissertation: 1) What is causing change in civil engineering; and 2) What is the nature of the changes? These two questions bring into focus the reasons why there exists an opportunity for civil engineering education reform. First, the literature review examines the underpinnings of civil engineering education reform. Then, I discuss the impetus for reform as a realization that major changes in engineering education are needed to meet 21st century challenges.

The preliminary sources in the literature search included indexes, databases, and literature searches comprised of refereed journal articles, meta-analyses and books. These indexes and databases included Minnesota Library system, American Society of Civil Engineers, Department of Education, Department of Labor, US National Academy of Engineering, National Academies and internet searches.

What is causing change in Civil Engineering?

Driving the dramatic change in today's civil engineering practice are Globalization, technology, Climate Change and Civil Infrastructure Deterioration - and they are likely to accelerate in the years ahead.

Globalization

Galloway (2003) asserts that the third millennium will present civil engineers with a new worldwide business landscape in which to conduct their business. *Arciszewsi (2006)* reinforces Galloway's claims by pointing to globalization as an agent of third millennium change. According to Arciszewsi (2006), "to survive, and especially to thrive, in the rapidly changing world, civil engineers must recognize the existence of driving forces such as globalization and to make significant changes in civil engineering education reflecting both tactical and strategic objectives" (pp. 27-28). Soibelman, Sacks, Akinci, Dikmen, Birgonul and Eypoosh, (2011) claim that economic globalization is increasingly affecting both the construction industry and academia. As a result, it is changing the traditional roles of civil engineers and construction managers (Soibelman, et al., 2011).

Russell, Hanna, Bank and Shapira, (2007) also attribute changes in civil engineering to globalization. In the article, *Education in Construction Engineering and Management Built on Tradition: Blueprint for Tomorrow*, the authors presume that because of globalization, the role of civil engineers to plan, design, build, and operate systems to serve the public welfare has taken on a new sense of urgency (Russell et al, 2007). These changes, according to Sheehan (2010), will require that civil engineering become more attuned to the concepts and rationales that underpin globalization. Ultimately, civil engineers should have a fundamental understanding based on the theory of complex adaptive systems (Arciszewsi, 2006).

Russell et al. (2007) recommend that engineers be educated to understand, balance and apply what they know amidst the complexities of the natural world, the built environment, and the needs of society. The authors also acknowledge that the challenge is one of constant innovation and execution: “to improve our standards of living, to meet the expectations of clients, to protect natural resources, and to inspire and prepare the next generation of engineers as scientists, sociologists, leaders, and business people” (p.663). They further recommend that for future construction and civil engineers to meet the needs of society, educators and those involved in professional practice as mentors and advisors must help prepare the future generation of engineering practitioners by integrating key concepts to enhance understanding globalization.

Technology

In their article, *Building Information Modeling in Architecture, Engineering, and Construction: Emerging Research Directions and Trends,* Becerik-Gerber and Kensek (2010), caution that the 21st century engineer must be able to deal with a rapid pace of technological change, a highly interconnected world, and complex problems that require multidisciplinary solutions. The fast-moving world of information technology (IT) confronts the civil engineer with constant change. To adapt to this dynamic world undergoing change, Grigg, Criswell, Fontane and

Siller (2005) recommend that the civil engineer must apply emerging IT tools to build and operate tomorrow's infrastructure and environmental control systems. For example, Computer-aided engineering (CAE) tools have been incrementally replacing manual methods in the traditional design process (Tippett and LaHoud, 1999). However, in recent years, the increasing availability of ever-more-powerful computing capacity has accelerated the rate of change in CAE technology (Tippett and LaHoud, 1999).

Information Technology is changing the nature of infrastructure and environmental systems management, especially monitoring and control. In systems management, IT is used to gather data and assist in decisions about distributed and embedded components. Grigg et al, (2005) identified infrastructure and environmental management systems that are changing rapidly as a result of IT: Intelligent Transportation Systems (ITS) such as advance warning signs and way-finding sign; Intelligent construction systems such as robotics, remote monitoring and data collection, and measurement for deflections during construction; Infrastructure assessment and nondestructive evaluation; Environmental monitoring and control systems such as Supervisory Control And Data Acquisition Systems (SCADA)and decision-support systems; Disaster management and early warning systems such as risk- and security-related issues that involve IT, like flood, earthquake, wind, and even human-caused threats; Smart buildings that are designed with many environmental controls and structural controls such as seismic isolation systems; and components of systems and relationships between components.

These technologies offer the potential of a paradigm shift at the most fundamental levels of design and construction engineering (Luth, 2011). Third generation computer technologies include 3D data base linked models, 3D visualization and conflict checking, and 4D (time) and 5D (cost) simulation and visualization, automated layout using GPS linked to precision models, and automated Computer Numerically Controlled (CNC) fabrication from precision 3D models (Luth, 2011).

Building Information Modeling (BIM) is the latest generation of Object-Oriented CAD systems (OOCAD) systems in which all of the intelligent building objects that combine to make up a building design can coexist in a single project database that captures everything known about the building. A building information model provides a single, logical, consistent source for all information associated with the building (Howell and Batcheler, 2004). The theory is that if every piece of data required to design and construct a project were entered and developed within a single system, the project could be constructed in the virtual world first (Thomson and Miner, 2010). The system could create dependable 3D models and add additional fourth and fifth dimensions of schedule and cost (Thomson and Miner, 2010). At the microscopic level, the application of creative engineering produces detailed construction management models through a collaborative effort of designers, builders, and users and will have a substantial effect on construction sequences (Luth, 2011).

At the nano-level, technology is also having a profound effect on civil engineering education and practice. Nanotechnology is one of the most active research areas that encompass several disciplines including civil engineering and construction materials (Mann, 2006). The construction business will inevitably be a beneficiary of this nanotechnology; in fact, it already is in the fields of concrete, steel and glass. Concrete is stronger, more durable and more easily placed, steel tougher and glass self-cleaning. Increased strength and durability are also a part of the drive to reduce the environmental footprint of the built environment by the efficient use of resources (Mann, 2006). Civil engineering is directly related to construction and thus to construction materials, the most representative of which are cement, concrete and steel as well as coatings (Karakasidis, 2011; Uskokovic, 2010).

Climate Change

Throughout history, the Earth has seen many fluctuations in its climate. However, the notion of manmade global warming originated in 1985 at a meeting convened by the UN in Villach, Austria (Dixon, 2009). Rising sea levels, increasing earth surface temperature, extreme rainfalls and floods, increasing, widening ranges in air temperatures, and depleting drinking water are all attributed to climate change.

In response to the many threats posed by climate change, world leaders must maintain, improve and develop new infrastructure, while also developing cleaner and more efficient fuels (Dixon, 2009). Civil engineers have an essential, and so far, under-recognized, role in responding to the climate challenge (Hall and Pidgeon, 2010). Civil engineering by definition is a profession that connects the manmade world with the natural world. The infrastructure systems civil engineers create today are vulnerable to the effects of natural hazards such as flooding, landslides, windstorm and coastal erosion (Hall, Dawson, Manning, Walkden. Dickson and Sayers, 2006). Civil engineers will inevitably be called upon to develop the infrastructure systems of tomorrow that will protect us from those intensifying natural hazards. Because civil engineering projects involve the amelioration of environmental problems, a new discipline of civil engineering is now evolving. The development of methods to engineer coupled natural, human and technological systems at a range of scales is becoming known as 'earth systems engineering' (Allenby, 2000).

Civil Infrastructure Deterioration

According to the latest report for U.S. civil Infrastructure, key components of the U.S. infrastructures are in such deplorable condition that it would take $2.2 trillion over five years to bring them up from a "D" grade to a "B" grade. To keep them at a "B" grade requires an annual investment of 6% of the nation's Gross Domestic Product. Yet in spite of increasing infrastructure preservation and improvement needs, and limited agency budgets, public and private agencies, and Engineering Education programs tend to focus primarily on designing and building new structures.

The American Society of Civil Engineers (ASCE) is bringing awareness to the wisdom of a holistic approach to Civil Engineering Education – from cradle to grave. This philosophy of a holistic solution to our infrastructure systems crisis promotes interdisciplinary approaches to planning, funding, building, and managing complex civil infrastructure systems to optimize their social, economic and environmental impacts. According to ASCE Infrastructure Systems have social, economic, political, environmental, legal, ethical and cultural implications and require a holistic approach to their solutions. A broad, holistic education has been shown to increase creativity and the ability to solve complex problems (Russell et al., 2007).

What is the nature of the changes?

Studies have explored the roles that the employer, nature of the work, and workplace culture play on a new engineer's experiences (Anderson, Courter, McGlamery, Nathans-Kelly and Nicometo, 2010; Strobel and Pan, 2011). Tilli and Trevelyan (2008) surveyed recent Australian engineering graduates and showed that about 60 percent of early career engineer professionals' time at work is spent interacting with others, highlighting the importance of social interaction in engineering practice. In another study involving in-depth interviews with eight engineers at a single firm, several themes emerged over their first eight to ten months of employment (Polach, 2004). Engineers appreciated their firm's easy-going atmosphere but were concerned about a lack of clarity on how they should spend their time. New engineers also acknowledged the importance of developing friendships at work, which was challenging for them, as well as building their social networks outside of work in their new city. Due to a lack of consistent feedback, many participants were uncertain if their performance was acceptable or felt guilty for not producing more. When they settled more into their positions, they expressed gratification for being able to finally, contribute and for overall satisfaction with their first year of work (Polach, 2004). Eraut's work with early career engineers, nurses, and accountants in England support these findings (2007). Through extensive interviews and observations, he found that education, sustainability, and cultural competences were crucial to enhance workplace effectiveness in this changing environment.

Education

Engineering Education has a rich history that dates back 5000 years. Throughout engineering history, events both natural and human induced, have change engineering practice and thus Engineering Education. In the twentieth century, Engineering Education in the United States has undergone a profound transformation, from a strong focus on engineering practice and design before World War II to a current emphasis on scientific fundamentals and mathematical analysis (Prados, 1998). Three initiatives contributed to this: the Mann Report of 1918 called for more laboratory training of engineers; the Accreditation Board for Engineering and Technology set up standards for engineering schools in 1932; and in the second half of the twentieth century, computers and computer programs refocused engineering education.

Because of a continued transformation of civil engineering into the 21st century, civil engineering governing bodies have developed new criteria for education and practice. According to the American Society of Civil Engineers (ASCE), civil engineers of 2025 will face a world quite different from that of today. (ASCE, 2006) predicts that:

> “An ever-increasing global population that continues to shift to urban areas will require widespread adoption of sustainability. Demands for energy,

drinking water, clean air, safe waste disposal, and transportation will drive environmental protection and infrastructure development. Society will face increased threats from natural events, accidents, and perhaps other causes such as terrorism" (p.1).

The ASCE is attempting to 'raise the bar' through the introduction of a Body of Knowledge (BOK) by which civil engineers are to satisfy their skill requirements for engineering practice. The intent of this initiative is to ultimately, change the present paradigm of quantitative and incremental improvements in civil engineering practice (Arciszewsi, 2006). The ASCE, through its published BOK, proclaims that the civil engineers must be informed, not only by mathematics but also by the humanities and social sciences.

In 1999, the Accreditation Board for Engineering and Technology (ABET) adopted Engineering Criteria 2000 (EC2000), to encourage adoption of a new engineering education paradigm (Borrego, Streveler, Miller and Smith, 2008; Radcliffe and Jolly, 2003; Wankat, Felder, Smith and Oreovicz, 2002). This new paradigm is in salutation with the body of knowledge proposed by ASCE. The new criteria focus on outcomes (what is learned) rather than what is taught. Student outcomes describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program. The Engineering Accreditation Commission of ABET recommend a broad education component that includes humanities and social sciences. The new set of accreditation criteria developed focuses attention on the goals of Engineering Education as expressed in the characteristics and abilities expected of graduates (Civil Engineering Body of Knowledge, Third Edition (CEBOK3), 2019; Radcliffe and Jolly, 2003). These characteristics include an understanding of professional and ethical responsibility and the impact of engineering solutions in global and social contexts (CEBOK3, 2019; Prados, 1998). To be accredited, instructional programs in engineering and engineering technology must now set forth learning objectives that involve both technical and interpersonal skills, assessment measures to determine how well the objectives are achieved and plans for taking remedial action to address shortcomings revealed by the assessment (Radcliffe and Jolly, 2003).

The National Council of Examiners for Engineering and Surveying (NCEES) has modified section 130.10 of its model law. The purpose of the law is to provide guidance to States as they craft legislation pertaining to licensure. Like the rules adopted by ASCE and ABET, the law was modified to encourage States to expand the body of knowledge requirements that include humanities and social sciences for the professional practice of engineering.

Sustainability

In recent years, there has been an increase in environmental stewardship practices and policies involving energy efficiency, water conservation, climate change, renewable portfolio standards, and other issues (Cui and Fang, 2012). These advances are expanding the boundary of future civil engineering practice (Cui and Fang, 2012).

Civil engineers and future civil engineers play a vital role in the sustainable development in meeting the needs of the public (Rodgers, 2009). As the stewards of society's physical infrastructure, civil engineers must lead in sustainable planning, design and construction. As stated by Duffell (1998), “The engineering profession must embrace the ethic of sustainability in engineering education and in practice” (p. 78). It is argued that Sustainable Development is now absolutely central to the practice of civil engineering and this needs to be reflected in the education and training of civil engineers (Jowitt, 2004). As such “a systems and process-based approach is advocated which depends on the development specific Attitudes, Systems Skills and Domain Knowledge” (Jowitt, 2004, p.1).

Brunel University (2012) predicts that the next few decades promise to be amongst the most challenging for the Civil Engineering community. Already increasing populations, progressive urbanization and ongoing economic development, not to mention climate change and the persistent risk of extreme events, present many threats to infrastructure (Brunel University, 2012). As a result, civil engineers need to draw deeply on their knowledge, skills and ability to innovate, to provide essential and sustainable infrastructure, including roads, bridges, tunnels, flood protection, and water supply and treatment systems. (Brunel University, 2012)

Civil engineers must learn to communicate the importance, function and impacts of civil infrastructure in daily life, and in sustainability terms, in order to assume a greater leadership role. Perks, Burrell, Korol, Khan, Heroux, and Ford

(2007) in their article, *Guidelines for Sustainable Development*, outlined a set of guiding principles for sustainable engineering. Specifically, they recommend that civil engineers should endeavor to recognize that the expertise required for a specific engineering activity might not be enough for judging the environmental implications of that activity. Specialists in environmental engineering and other professions are in need to determine the environmental implications of engineering activities. However, the rights of the community must be considered. The community should be involved in project formulation and development, and the engineer should actively encourage such involvement. According to the guidelines, the civil engineer should endeavor to: Establish operational goals and targets aimed at energy and resource conservation; Promote and follow performance-based standards and guidelines; Incorporate appropriate monitoring of environmental change into all operations and processes; Ensure close liaison between the design and operational phases of projects; and, Advocate for sustainable funding for operations and maintenance during the entire life cycle of each project.

Global Competence

Globalization has led to new forms of teams that are diverse in age, education, culture, ethnicity, language, and geographic location (Tomek, 2011). Tomek (2011) concludes that “like teams in business, consulting, and military operations, which have become multicultural, cross-generational, and multidisciplinary to address the new and emerging challenges of operating in a globalized world civil engineering project teams have found that team development is not just necessary, but critical to optimal performance and, ultimately, to mission or project success" (p. 191).

There has been a vigorous debate within the worldwide engineering community concerning the importance of preparing engineers for transnational practice and a global society (Lohmann and Hoey, 2005). The 21st Century engineering professional now requires competence beyond technical skills. Globally competent engineers and technologists must possess the capabilities and attributes that are required for excellent performance in today's multicultural and global society (Ayokanmbi, 2011). Cross-cultural collaboration and communication skills, multinational team management skills, the ability to overcome the social challenges of geographically distributed teams, familiarity with construction materials, standards, and methods in other countries are vital for modern construction professionals (Soibelman, Sacks, Akinci, Dikmen, Birgonul, Eybpoosh, 2011). However, Soibelman, et al. (2011) believe the traditional skills and education style of engineers and construction managers do not equip them to successfully deal with such issues.

The reason for their skepticism is that, "while many aspects of society and commerce have become internationalized, it cannot yet be said for many university curricula that they prepare students to live and work in a global community, especially engineers" (p. 141). Downey, Lucena, Moskal, Parkhurst, Bigley, Hays, Jesiek, Kelly, Miller, Ruff, Lehr and Nichols-Belo (2006) laid out a clear path of learning criteria and outcomes for global competence. The global competence proposed by Downey et al. (2006) consists of: *Knowledge-*

geographic, geopolitical, world history, current world events and most importantly specific knowledge of cultures starting with in-depth knowledge of one's own; *Skills*- communication (language, written and oral), teamwork, the ability to participate socially and in business settings in other cultures, the ability to cope with unfamiliar situations, and the ability to use appropriate technology to effectively communicate over long-distances; and *Attitudes* - openness towards engaging and learning about other cultures (Lohmann, Howard, Rollins and Hoey, 2005; Widmann and Vanasupa, 2008).

Civil Engineering as a Result of Change

In the past, changes in the engineering profession and engineering education have followed changes in technology and society. Disciplines were added and curricula were created to meet the critical challenges in society and to provide the workforce required to integrate new developments into our economy. Today's landscape is a little different; society continually changes, and engineering must adapt to become more responsive.

In recent years, several scholars have called for a humanistic approach to civil engineering as a way to foster greater cultural and social understanding and develop flexibility and adaptability in civil engineers. Humanistic Engineers according to Fisher and Mahajan (2003), are able to initiate and engage in effective dialogue with non-technical audiences regarding socio-humanistic critiques of engineering processes and products; and in forming judgements, they are able to perform their own socio-humanistic critiques in the absence of such dialogue.

Humanities, Social Thought and Engineering

"In an increasingly complex world, there exists a need for an interdisciplinary, [humanistic] approach to engineering that includes the expansion of a dialogue that integrates the humanities and the social sciences with engineering" (Grasso, Callahan and Doucett, 2004, p. 413). The Commission on the Humanities and Social Sciences, in their report to Congress, titled *"The Heart of the Matter"*, describes the societal importance of humanities and social sciences as follows:

> "As we strive to create a more civil public discourse, a more adaptable and creative workforce, and a more secure nation, the humanities and social sciences are the heart of the matter, the keeper of the republic—a source of national memory and civic vigor, cultural understanding and communication, individual fulfillment and the ideals we hold in common. They are critical to a democratic society and they require our support."

In recent years, there has been more emphasis on the importance of the social impact of engineering activities. Baillie (2006) acknowledges this development, arguing that:

> "Engineering forms part of a complex mix of social, political and economic developments. We are involved with serious problems at a local and Global level that affect our society and the environment. Perhaps if engineers could study more about the social, economic and political context of their profession they might apply their creativity to employ what the scholars and practitioners in other fields have been discovering. We

hope that engineers might then work together with the future graduates of sociology and political economics and with the broader communities in order to redefine engineering practice. Understanding the "social impact" of our engineering is not as simple as exploring the potential health and safety risks or ensuring that we are legally covered for liability. In whatever way is possible, we need to ensure that procedures are in place to critically examine our own engineering practices and study the implications of such practices on local and global societies." (pp. 63-64)

Social responsibility is another term that is frequently used in the current economic and social climate. According to Zandvoort (2007), there is much agreement on the importance of preparing engineering graduates for social responsibility. Bielefeldt and Canney (2014) also state:

> "Engineers are increasingly being called on to fully embrace their responsibility as professionals to serve the public and consider the societal implications of their work. These attributes may be termed "professional social responsibility". The spectrum of activities that embody professional social responsibility span from encouraging a diverse range of stakeholders to be engaged in the engineering process to social justice issues." (P. 47).

A succession of key factors has shaped civil engineers' sensitivity from distinctive technocratic attitude to social impact and responsibility or what Strobel, Wachter, Weber, Dyehouse, Klingler, and Pan (2011) refers to as *ethical sensitivity*. Picon (2007) points to the connection engineers established between material and moral progress, as well as the conviction held by engineers that they are indeed serving public welfare. Picon (2007) also attributes the change in engineers' attitudes to changing societies and the emergence of "new generations that were no longer ready to accept passively technological policies developed in the name of public welfare by State engineers." (p. 5). Another factor shaping contemporary engineers' sensitivity is the recognition of local communities as key stakeholders. With the increasing recognition of Indigenous human rights, and the institutionalization of impact assessment for large-scale projects, local communities are now recognized as key stakeholders (O'Faircheallaigh, 1999). The humanities and social sciences play an important role in shaping an engineer's social thought in the identification, formulation, and solution to engineering problems (Adams, 2004). This assessment of social thought has introduced a discourse that advocate for social thought as a guiding principle of engineering practice.

Social thought. Social thought is that branch of thought which is primarily concerned with human-beings' general social life and its problems as created, expressed and endured by human interrelations and interactions (Bogardus, 1960). Social theory looks to interdisciplinarity, combining knowledge from multiple academic disciplines in order to enlighten complex issues, and draw on ideas from diverse fields. In the strict sense, social thought is the product of the thinking together as a group.

Bogardus (1960) identifies three types of social thought: (i) Social beneficial thinking, (ii) Negative or antisocial thinking, and (iii) Positive or scientific social thinking.

Social beneficial thinking. Socially beneficial thinking is usually comprised of progressive or constructive social proposals, which are designed to bring about progressive changes in the society (Rashmi Priya, n.d.).

Negative or antisocial thinking. Negative Social thinking is characterized by selfishness, disregard of general welfare. In this negative type of social thinking, the welfare of the majority is not taken into consideration. Only interests of the few in either power or authority or those who can manipulate the situation in their favor take advantage of the situation (Rashmi Priya, n.d.)

Positive or scientific social thinking. Scientific thought is that type of thought based on each social event, problems etc. Scientific social thinking is impartial and unbiased (Rashmi Priya, n.d.). It is a type of thinking which promotes collective welfare. This type of thinking can be scientifically considered or analyzed.

Modes of humanities. Creating solutions to socio-technical problems requires a knowledge of human behavior. Tackling today's biggest social and technological challenges requires the ability to think critically about their human context. The design of an engineering solution today requires a sense of empathy that comes from the humanities. The American Council of Learned Societies describes the humanities as, "comprise [of] those fields of knowledge and learning concerned with human thought, experience, and creativity."

Stanford Humanities Center explains that, "The humanities can be described as the study of how people process and document the human experience. Since humans have been able, we have used philosophy, literature, religion, art, music, history and language to understand and record our world. These modes of expression have become some of the subjects that traditionally fall under the humanities umbrella."

McPhail, (2001) argues that if the objective of ethics education is to help students appreciate how their actions affect others, the humanities might be able to help in two ways. Firstly, developing ethical sensitivity involves entering into the feelings and emotions of other sentient human beings. The humanities may provide us with the material, the poems, literature and music whereby students can begin to engage with the individuals behind the categories they conventionally work with (Morgan, 1988). Secondly, the humanities can provide a basis for exploring different ways of knowing (McPhail, 2001). The epistemology of a piece of poetry or prose, for example, can provide the basis for exploring different ways of knowing and for critiquing the assumed rationality (Morgan, 1988). Engineers, particularly those who work for transnational resource companies, often confront different belief systems when they work on site. (Armstrong and Baillie, 2012). “All social theories make assumptions about the nature of reality” and “all social theories make assumptions about how we know what we know” (Best, 2003, p.8). It is worth understanding that these realities, these beliefs, provide a particular stance or position engineers may want to arrive at after deliberating on a social analysis (Best, 2003).

Knowledge and Knowing

At the end of the 19th century, law schools concluded that they could no longer teach all of the vast number of laws that had accumulated over time and decided instead to teach students how to think like lawyers. So too, at the beginning of the 21st century, civil engineering has shifted its focus to teaching students how to think like engineers (Grasso and Martinelli, 2007). In conjunction with the drive towards human-centered design in engineering, questions arise regarding how students build and engage a socially aware engineering identity, and how this identity points towards beliefs about the nature of reality. Carberry, Ohland and Swan (2010) argue that differing epistemological views construct different foundations for how students develop, conceive of, and employ human-centered approaches in their work. Epistemology of engineering addresses the questions of how we come to know engineering, what engineering learning is, and what constitutes engineering thinking and knowledge (Carberry, Ohland and Swan, 2010).

Research on how engineers engage with sociotechnical complexity, including comparing evidence from multiple disciplinary perspectives and epistemologies, conducted to reveal characteristic barriers to engineering development, and methods to externalize felt contradictions. The purpose of such research is to explicate the epistemological beliefs and ontological viewpoints that engineering students activate when engaging in engineering activity.

Engineering Epistemological Belief and Attitude. There are three important components of engineering education and practice influencing engineering epistemology and ontology: knowledge, skill and attitude (Hanzah, Ismail and Md Isa, 2012). Knowledge is defined as facts and concept of engineering such as the practical application of engineering science, the application of fundamental mathematics principles and design modeling. The skills are those used by engineers in managing and applying their knowledge in solving problems such as critical thinking and problem comprehension. Whilst, attitude is how engineers use their skill and knowledge through personal values, concerns, preferences and biases toward their professional goal (Hanzah, Ismail and Md Isa, 2012). Some scholars have concluded that the failure of engineering curricula to address attitudes and values systematically has had regrettable consequences. According to Rugarcia, Felder and Woods (2000), most of the times engineers make decisions without feeling a need to consider any of the social, ethical, and moral consequences of those decisions. Engineers believe that those attitudes and values are someone else's responsibility (Rugarcia, Felder and Woods, 2000). The challenge is to prepare a knowledgeable generation, particularly having the knowledge, skill and attitude beyond the range of traditional engineering curriculum. Thus, the focus of engineering education has shifted from the simple presentation of knowledge to the concept of integration of knowledge.

To make sense of this epistemological and ontological perspective, I rely upon Nelson and Stolterman (2012) understanding of how epistemologies and ontologies are intertwined in engineering praxis, where an ontology is the nature of being or what makes something “real” to us, and an epistemology is a way of thinking about or engaging with that reality. Engineering epistemological beliefs, the beliefs students hold to be true about the nature of engineering knowledge and the nature of knowing engineering is a foundational subject in engineering praxis.

Concept of knowledge and knowing. Hofer and Pintrich (1997), through their meta-analysis of engineering epistemological beliefs categorized four dimensions of nature of knowledge and the nature of knowing. These factors concerned students’ beliefs regarding the nature of engineering knowledge, certainty of knowledge and the simplicity of knowledge; and the nature of engineering knowing, source of knowing and the justification for knowing. Carberry, Ohland and Swan (2010) expanded Hofer and Pintrich four factors into a thirteen-item instrument, to generalize where engineering student cohorts fall on a naïve to sophisticated scale. The thirteen items instrument, comprising the four factors, are outlined in Table 2.1

Table 2.1. Carberry, Ohland and Swan thirteen item instrument to measure engineering epistemological beliefs	
Certainty of Engineering Knowledge	
1	There is often an ideal solution for engineering design problems
2	Most engineering principles are set in stone and cannot be argued or changed.
3	In most instances, traditional engineering ideas should be considered over new ideas.
Simplicity of Engineering Knowledge	
4	Engineering involves more than collecting information and developing solutions.
5	When engineers don't understand an engineering concept, they should just ignore it and move on.
6	A good engineering textbook should show how the material in one chapter relates to the material in other chapters.
Source of Engineering Knowing	
7	If an engineering student is having trouble in an engineering course, studying in a different way could make a difference.
8	Someone who lacks natural engineering ability most likely cannot learn engineering.
9	Most people can learn to think more like an engineer if they are given enough time.
Justification for Engineering Knowing	
10	Students usually understand engineering better when they present their solutions to their classmates and teachers.
11	Engineering students learn best when a teacher or expert transmits his or her knowledge to them.
12	Engineering textbooks written by engineering experts present the best way to learn engineering.
13	Being good at engineering is a talent someone is either born with or not.

Though Carberry, Ohland and Swan (2010) do not differentiate naïve engineering epistemological beliefs from sophisticated engineering epistemological beliefs, I extrapolate and assigned distinctions from previous literature. Among researchers who study students' epistemologies, a broad consensus has emerged about what constitutes a sophisticated epistemological stance toward scientific knowledge (Elby and Hammer, 2001). Hofer and Pintrich (1997) promote what constitute sophisticated beliefs about the nature of knowledge, which I assigned to engineering beliefs. Specifically, most researchers believe that students should come to understand scientific knowledge as fundamentally tentative and evolving, rather than certain and unchanging; subjective in the sense that it reflects scientists' perspectives, rather than objectively inherent in nature; and individually or socially constructed rather than discovered. In addition, students should come to see scientific knowledge as a coherent, hierarchical system of ideas, rather than as a simple collection of facts.

Epistemic cognition. According to Chinn, Rinehart and Buckland (2014), epistemic cognition refers to the complexes of cognitions that relates to the achieving epistemic ends. It refers to understanding the process of knowledge construction. For example, you are told that global warming has been linked to human activity. Do you believe this and why? Your belief about this link is shaped by your epistemic cognition, your understanding of how knowledge about the link between global warming and human activity is constructed. For example, your reasoning will differ if you expect science to produce exact answers, if you assume, we can never know one way or the other, or if you accept that, we cannot know for sure.

When it comes to designing an engineering system and bringing that project to fruition, engineers will encounter cultural and social diversity. It is an expectation for engineers to understand, and resolve, the complicated problems arising from cultural and social diversity and diversity of beliefs that attend any of these projects (Armstrong and Baillie, 2012). In dealing with these problems, developing sophisticated perspectives in the domain of epistemological beliefs is strongly advantageous to engineers (Greene, Torney-Purta and Azavedo, 2010). In the domain of moral development, more mature moral judgment enables engineers to take other's perspectives, to consider the complicated nature of moral dilemma, and present better solutions (Colby, Kohlberg, Gibbs, Lieberman, Fischer and Saltzstein, 1983). This sophisticated level of moral judgment is essential to make a proper moral decision in the field of engineering, because a lot of conflicting social values and factors are involved in those kinds of problems (Bell and Lederman, 2003).

Ethics, Professionalism and Morality

Theodore Roosevelt once said, "To educate a person in mind and not in morals is to educate a menace to society". In keeping with that sentiment, professions have established ethical standards for their practitioners. As professionals, we are expected to develop a moral compass by which we respond to ethical challenges that arise in professional practice. These challenges require solutions that protect the health, safety, and welfare of the public. Professional ethics are commitment to ethical and honest practice mandated by the profession's responsibilities.

However, professional ethics and morality is often the subject of debate. The reason for this debate is rooted in the definitions of the terms, ethics, morality and professionalism. Ethics is a system of moral principles; it is a philosophical gourmet of rules, principles, or ways of thinking that claim authority to guide the actions of a particular group. Morality on the other hand is concerned with a code of conduct put forward by society that distinguishes between good and evil or right and wrong. (Carr, 1999) outlines five principle criteria of professionalism as follows: (i) provide an important public service, (ii) theoretical and practical expertise, (iii) a code of ethics, (iv) organization and regulations, (v) high degree of autonomy.

When discussing professional ethics, it is important to distinguish between moral and ethical behavior for two reasons: (1) ethics has in its definition, the word 'moral'. If ethics is a system of moral principles and morality is a code of conduct that distinguishes between right and wrong, then it makes sense that the definition of professional ethics is a system of principles, which guides a profession in distinguishing right and wrong conduct. (2) People have a different array of value obligations when functioning as professionals or in their personal lives. A professional has specialized knowledge that are applied to serve four entities: the employer, the client, the profession, and society.

Inherent in the exercise of engineering expertise is the provision of useful, if not essential, services to clients, employers, customers, and the public.

Usefulness, quality, safety, efficiency, and cost effectiveness are not secondary features of this activity. They are its heart. So are reliable judgement and trustworthiness. Therefore, if we examine what engineers do, and not simply the technical content of engineering textbooks, it is easy to see that ethical responsibility should be a central concern of the engineering profession and practice (Harris, Davis, Pritchard and Rabins, 1996). Stephen Mraz (2009) tells a story about Herbert Hoover as follows:

> "Herbert Hoover used to tell of meeting a woman on a ship while traveling. After several conversations over a week or so, the woman asked what his occupation was. Hoover told her he was an engineer, a mining engineer. And the woman replied, "An engineer? I thought you were a gentleman." It seems the lady, like many people of her time, assumed engineering was not a gentlemanly career. It appears this lack of understanding and respect from society still haunts the engineering profession today, especially compared to the public approbations given to doctors, lawyers, and scientists. Engineering is an important and learned profession. Engineering applies a variety of factors to a situation in order to find a solution to an existing or potential problem. According to the National Society of Professional Engineers (NSPE), as members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the

protection of the public health, safety, and welfare (NSPE, 2003). International, federal, state and local laws govern engineering and engineering business. However, our interest is in solving conflict with ethics where there is no legal guidance. To accomplish this, we look to a code of ethics." (p. 15)

Engineering ethics seeks to go beyond the dictates of the law and provide a framework for ethical judgment. These Codes of Ethics are resources that are available to an engineer as a starting point for ethical decision-making. They help guide solutions to complex problems. These codes of ethics are dictated by four guiding principles and seven fundamental canons. Engineers uphold and advance the integrity, honor and dignity of the engineering profession by: 1) Using their knowledge and skill for the enhancement of human welfare; 2) Being honest and impartial, and serving with fidelity the public, their employers and clients; 3) Striving to increase the competence and prestige of the engineering profession; and 4) Supporting the professional and technical societies of their disciplines.

As outlined by the NSPE, the Fundamental Canons are: 1) Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties; 2) Engineers shall perform services only in the areas of their competence; 3) Engineers shall issue public statements only in an objective and truthful manner; 4) Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest; 5) Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others; 6) Engineers shall act in such a manner as to uphold and enhance the honor, integrity and dignity of the profession; 7) Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional development of those engineers under their supervision.

Philosophy of a Holistic Approach to Civil Engineering

Holistic engineering is by no means a well-defined term. It is, however, a term widely used by various actors to point to a different and better way of doing engineering (Buch, 2016; Tien, Namasivayam and Gamboa, 2015). “For centuries, society’s problems have been sufficiently linear, mechanistic, and discrete to be served by engineers responsible for solving problems through the application of math and science” (Grasso and Martinelli, 2007, p. 1). Today, the classic definition of engineering no longer serves us well. Pursuing the holistic concept of the “unity of knowledge” will yield a definition of engineering more fitting for the times ahead (Grasso and Martinelli, 2007). The unity of knowledge, first proposed by James Marsh, president of the University of Vermont in the early 1800s, is fundamentally about integrating knowledge across disciplines to deal with complex problems and better serve humanity (Grasso and Martinelli, 2007).

In 1902, David Starr Jordan, President of Stanford University, stated that there are many things besides engineering that go into the making of a real engineer. In this evolving world, a new kind of engineer is needed, one who can think broadly across disciplines and consider the human dimensions that are at the heart of every design challenge. Grasso and Martinelli (2007) advocate for changing the scope and significance of what engineering is and who engineers are. They describe the new civil engineer as technically adept people who serve humanity through the application not simply of math and science, but of a wide array of disciplines. Civil engineering is a discipline that purports to design for humanity and improve the quality of life. To better serve humanity, the civil engineering profession must be democratic and efficient. The civil engineers must understand the human condition in all its complexity, which requires the study of literature, history, philosophy, psychology, religion, and economics, among other fields (Grasso and Martinelli, 2007; Mahmoudi, Jafari, Nasrabadi and Liaghatdar, 2012).

Engineering and Democracy

The Institute for Democratic Education in America (IDEA) defines democratic education as "learning that equips every human being to participate fully in a healthy democracy." Its outcomes are the attitudes, knowledge, and skills that prepare college students for meaningful participation in a pluralistic and diverse democracy (Gurin, Dey, Hurtado and Gurin, 2002; Hurtado, 2003). By its definition and supposed outcomes, Democratic Education is an educational ideal in which democracy is both a goal and a method of instruction. For purposes of this dissertation, I restrict this discussion to the merits of Democratic Education to professional practice.

According to Ayres (2008), in her review of Albert Dzur’s book, *Democratic Professionalism: Citizen Participation and the Reconstruction of Professional*

Ethics, Identity, and Practice, during the Progressive Era, intellectuals such as John Dewey recognized the importance of specialized knowledge as uniquely capable of solving social problems and making difficult policy choices in the best interests of the public. Dewey's ideas for higher learning also relates to professional levels of education. Drawing from the agricultural extension services of universities, Dewey (1927) suggests extension roles for other schools including science and engineering. By introducing relevant literary materials, narrowly technical and occupational studies can be humanized. Almost fifty years after Dewey's death, Hyslop-Margison and Graham (2001) continues the argument for humanized occupational study. They argue that by adopting principles for democratic learning, career-education is strengthened, and critical thinking is expanded to consider the entire context of a particular problem.

In his assessment of the relationships between democracy and education, Lipset (1959) argued, "Education presumably broadens men's outlooks, enables them to understand the need for norms of tolerance, restrains them from adhering to extremist and monistic doctrines, and increases their capacity to make rational electoral choices." (p. 79). Lipset (1959), in quoting James Bryce (1919), further defines Democratic Education by stating: "education, if it does not make men good citizens, makes it at least easier for them to become so" (p. 79). Bryce did not define "Good Citizenship", however, in his book, *The Hindrance to Good Citizenship*, he identified what he considers to be hindrances to good citizenship, namely, Indolence, Selfish Personal Interest and Party Spirit. A relatively more recent definition of "Good Citizenship", and apropos contemporary discourse, is by Paulo Freire (1972). Freire's perception of a "Good Citizen" is someone who pursues a sustainable society, who participates in the process of humanization and the transformation of society through overcoming the barriers between people and creating unity based on common humanity.

The work of engineers is described by the consequences of their actions, and not from a natural scientific perspective (Korte, 2015) and is therefore inherently humanistic. Engineering work is necessarily entangled with non-engineering human systems in all of their complexity, subjectivity, and unpredictability (Korte, Mina, Omidvar, Frezza and Nordquest, 2015). Therefore, bringing expert knowledge to bear when solving social problems, with little or no input from the general public, is a major concern (Dzur, 2008). Albert Dzur, in his book, *Democratic Professionalism: Citizen Participation and the Reconstruction of Professional Ethics, Identity, and Practice*, proposes an approach he calls "democratic professionalism" to build bridges between specialists and the lay public in such a way as to enable and enhance broader public engagement and deliberation about major social issues. Dzur's perspective is that professionals, while still valuing the specialized knowledge of their profession, can be more democratic by working collaboratively with lay people, enabling them to deliberate and make decisions on issues that affect them.

Education through a community of practice tends to socialize its members, but the quality and value of the socialization depends upon the habits and aims of the community. Thus, Dewey (1916) selects two points by which to measure the worth of a form of social life: 1) “the extent in which the interests of a group are shared by all its members”; 2) “the fullness and freedom with which it interacts with other groups” (p.115). Hence, “democratic professionalism” require acquainting practitioners with both the history and the current state of cultures from various disciplinary stances, as well as social efficiency of practice.

Social Efficiency and the Culture of Professional Practice

In the 1970s, Walter H. Drost, David Snedden’s biographer, revived the debate with Dewey in order to introduce Snedden to a modern audience (Labaree, 2010). Snedden argued that “social economy” calls for a system of vocational education that prepares the “rank and file” to become efficient “producers,” asserting that this form of schooling needs to be separated from liberal education. Snedden advocated for total separation of vocational education and liberal education after primary level. To him, vocational education differs from general, or liberal, education fundamentally as regards its essential aims, and that, therefore, it will differ also, fundamentally, as regards the means and methods of instruction, as well as the administrative agencies, which are intimately related to means and methods of instruction. He further contended that vocational education and liberal education cannot be effectively carried on, so far as regards a given group of pupils, in a way which permits of a considerable blending of the unlike types of instruction. To attempt this is to defeat the aims both of liberal and of vocational training.

To get a sense where engineering resided in the debate, a few words on the history of engineering education in the United States may be helpful. Early engineering schools were little more than vocational institutes that taught current industrial practice following a pedagogy that had been developed a century earlier in Europe (Kulacki, 1999). Between 1840 and 1890, educational specialization began, and the professional engineer emerged. However, the transformation of the content of the engineering curriculum to a mathematical and applied science basis began only as recently as the 1940s, largely because of the World War II effort (Kulacki, 1999). Mathematics and science resided in the department of natural philosophy, and existing universities were oriented toward the humanities, law, and medicine.

Historically, vocational education in the United State has concentrated on technical competences. The curricula have traditionally been geared towards the technical education in the United States has parallel that of the economy. Technical education has followed David Snedden's philosophy; a philosophy that technical education should lead to a specific skill for gainful employment. However, the future seems to call for a different approach towards technical education. The approach now being proposed by industry, government and education officials was once advocated by John Dewey. Dewey believed in a more comprehensive and democratic form of technical education. He saw wisdom in a combined technical-liberal education system he called industrial education. Such an education, he advocated, would develop initiative and personal resources of intelligence.

John Dewey viewed Snedden's ideas on education as simply trade training. Dewey believed in a more comprehensive and democratic form of education. He saw wisdom in a combined technical-liberal education system he called industrial education. Such an education, he advocated, would develop initiative and personal resources of intelligence. Bagley (1914) asserted that Snedden's distinction between education for production and utilization merely reproduced the old discredited distinction between education for gentlemen of leisure and education for workers. Both Dewey and Bagley took exception to Snedden's perspective of social efficiency as being a measure of product or output. Dewey contended that the separation of the two aims in education – social-efficiency and culture – is fatal to democracy; and that narrowing the meaning of efficiency deprives it of its essential justification (Dewey, 1916). According to Dewey (1916), "…social efficiency as an educational purpose should mean cultivation of power to join freely and fully in shared or common activities. This is impossible without culture …" (p.79). To eliminate the "philosophic dualisms", he offers the following argument:

> "A vocation means nothing, but such a direction of life activities as renders them perceptibly significant to a person, because of the consequences they accomplish, and also useful to his associates […]
>
> Occupation is a concrete term for continuity. It includes the development of artistic capacity of any kind, of special scientific ability, of effective citizenship, as well as professional and business occupations, to say nothing of mechanical labor or engagement in gainful pursuits. We must avoid not only limitation of conception of vocation to the occupations where immediately tangible commodities are produced, but also the notion that

> vocations are distributed in an exclusive way, one and only one to each person. Such restricted specialism is impossible; nothing could be more absurd than to try to educate individuals with an eye to only one line of activity." (Waks, 2016, pp.191-192).

Presently, the conflict of philosophical theories focuses discussion of the proper place and function of human and societal factors in engineering education. Moreover, the words of John Dewey ring true today as they did in 1916: "there seems to be too great a gap between the remote and general terms in which philosophic ideas are formulated and the practical and concrete details of vocational education." (p.191). There is a growing notion that the public interest and the public good are not well served by the traditional professions and the newly professionalized vocations (Kulacki, 1999).

The fallacy is in the adaptation of an ideology that measures of humanities and social science are in subordination rather than of utilization to secure efficiency. We should recognize that "social efficiency is attained not by negative constraint but by positive use of native individual capacities in occupations having a social meaning" (Waks, 2016, p.54).

It goes without question that all social institutions in a democratic society have a responsibility to improve the policies, practices, and processes that are a part of its fabric. Engineering and the engineer are uniquely responsible for the built environment (Kulacki, 1999). The artifacts of life and the means by which we judge our quality of life are the results of engineering. Engineering is inherently holistic. However, "the sheer increase of specialized knowledge will never work the miracle of producing an intellectual whole. Nevertheless, the need for integration of specialized results of science remains, and philosophy should contribute to the satisfaction of the need" (Dewey, 1929, p.249).

According to Khalid Kadir, Professor at UC Berkeley, "Engineers draw a box around a technical problem. We have inputs and outputs and we deal with what's inside the box. We don't look beyond what's inside the box, we don't look at the whole picture because that's not what our current training tells us to do." In his argument for holism in engineering, Kulacki (1999) points to Julius Stratton of MIT who said in his commencement address in 1958:

> "[F]or all their common ground, engineering is not and never will be science. There is inherent in the profession a whole set of attitudes and concepts completely foreign to pure science. The engineer must have a feel for materials, a concern for cost, and understanding of the factors of size and width, an appreciation of the problems of maintenance and replacement, and above all, an unfailing sense of responsibility toward his client and the public good."

Critical thinking is salient to engineering problem solving. However, "critical thinking just doesn't happen in courses where you are trying to figure out problems using mathematics or physics," says Oscar Dubón, the associate dean at Berkeley Engineering. Civil engineering problems often involve complex or unclear social, political and economic issues. Therefore, the goal should be to create a culture of professional practice and professionals that are better equipped to tackle large social problems and to understand their ethical responsibilities as technical experts.

Civil Engineering Practice

Increases in human population, a growing reliance on information technology, the onset of a truly global economy, shrinking project timescales, and a complex and degrading infrastructure will continue to challenge and change civil engineers' practice (Bordogna, 2001; Grigg, 2000; Little, 1999). The need for well-qualified engineers could not be more critical (Russell and Stouffer, 2003). To account for the challenges and complexities confronting the profession, many within ASCE have begun to formally reevaluate the civil engineering professional practice (ASCE, 1998; Liggett and Ettema 2001; Russell, Yao, Farr, Walesh and Bishop 1996; Wulf 1998; Sparrow 2001; Yao and Roesset 2001). Today's civil engineers are expected to simultaneously, possess broader capability and greater specialized technical competence than their predecessors. According to Russell and Stouffer (2003, p.3), "Together, these professional skills comprise a significant portion of the new skill set needed to safely and effectively practice civil engineering in the 21st Century (Bernhardt and McNeil 2001; Little 1999; Yao and Roesset 2001)". Specifically, according to BOK3 criteria, the 21st century civil engineers, in addition to the technical disciplines, must be able to identify, explain and apply subjects in the humanities and social sciences.

Application of science and engineering. Science and Engineering are fundamentally different, though their application depend on each other. In assessing the BOK, it is necessary that we differentiate and associate these disciplines. It may be argued that the two-culture problem in undergraduate engineering education is an inherited one. That is, the original two-culture problem, as articulated by Snow (1964), is between the culture of science and the culture of the humanities. Because of the fundamental role of natural science in engineering education, the two-culture wedge has split engineering and humanities just as it has science and the humanities (Adams, 2004). However, engineering problems differ from scientific problems. Therefore, the proper identification, formulation, and solving of engineering problems require an understanding of the distinction between engineering and science (Adams, 2004).

Science and engineering have disciplinary knowledge, skills, and ways of experiencing the world. Design is widely considered the distinguishing activity of engineering. By using the design process, engineers can integrate various skills and types of thinking – analytical and synthetic thinking; detailed understanding and holistic understanding; planning and building; and implicit, procedural knowledge and explicit, declarative knowledge (Silk and Schunn, 2008).

Engineering design is often compared with scientific inquiry, and, indeed, the two approaches have a number of similar features. However, they also differ in significant ways. The goal of engineering design is primarily about designing products or processes that result in predictable outcomes, often maximizing those outcomes as outputs given constraints on resources as inputs to the design. Nevertheless, in all real-world products or processes in need of an engineering solution, there are usually a large number and wide range of input variables that can be manipulated in the design of an effective solution. Knowing which of those variables have a causal effect on the outcome is thus of central importance in engineering design (Silk and Schunn, 2008). These are fundamental characteristics of design that set it apart from the practice of science.

One point of divergence between engineering design and scientific inquiry is the role of constraints, which are common to both processes but are fundamental to engineering design. Specifications and constraints are not essential to answering scientific questions. However, they are essential to understand the requirements of the design. Specifications are key features and elements of a product and its function. Constraints are limitations on the design – physical, financial, social, political, environmental factors, and so on (American Association for the Advancement of Science, [AAAS], 1989). Judgments about the suitability of a design are inevitably shaped by individual and social values; thus, the optimal design for one person may not be optimal for another, this is quite different from the scientific method. In the ideal scientific situation, answers are independent of values (Silk and Schunn, 2008). Determining the best solution to a technical problem requires balancing competing or conflicting factors; this process is called optimization. Often different alternatives are better in different ways. Choosing the best solution normally requires trade-offs, that is, deciding not to maximize one desirable thing in order to maximize another. Deciding which criteria are the most important is essential to determining the best solution to a problem. The idea is to decide upon a design that comes closest to meeting the specifications, that fits within the constraints, and that has the least number of negative characteristics. Another difference is the scientist's emphasis on finding general rules that describe as many phenomena as possible, whereas the engineer's focus is on finding solutions that satisfy particular circumstances. Scientific inquiry begins with a particular, detailed phenomenon and moves toward generalization, while engineering design applies general rules and approaches to zero in on a particular solution.

Summary of the Chapter

The context within which civil engineering lessons are taught should reflect the way the knowledge will be used in real-life including the complexity of the real-world situation, providing purpose and the possibility for extended exploration. The problems civil engineers encounter requires collaborative searches for suggestions and solutions to promote critical thinking. The socially responsible engineer takes the entire environment or situation into consideration when problem solving. It is a logical conclusion that what is being advocated is a holistic development of the civil engineer, and the making of a certain quality of citizen. We are responsible for the trends of thought and actions of our time. As such, holistic engineering focus is on providing the right education to help civil engineers to take up the responsibility and make the right decisions that includes social human concerns. Decisions that go beyond the mere application of mathematics and science and considers a few of the non-technical subjects most often identified as relevant and important for engineers.

Chapter III: Methodology

To get an in-depth understanding of the civil engineer's experiences as they transition from being undergraduate students to entry-level positions, a qualitative research approach was selected. Specifically, this study used grounded theory methodology to investigate the humanities and social sciences that influence undergraduate civil engineers for entry-level engineering practice, as there is a lack of research on civil engineering student readiness for professional practice. Grounded theory provided a methodology to develop an understanding of social phenomena that is not pre-formed or pre-theoretically developed with existing theories and paradigms (Engward, 2013).

Grounded theory originated from sociology on the premise that meaning is negotiated and understood through interactions with others in social processes (Blumer, 1986; Jeon, 2004). Glaser and Strauss (1967) described grounded theory as developing an explanatory theory of basic social processes, studied in the environments in which they take place. Grounded theory has two distinctive aspects: constant comparative analysis and theoretical sampling (Glaser and Strauss, 1967). Their premise was that theories should be grounded in data from the field, especially the actions, interactions, or processes through interrelating categories of information based on data collected by the researcher (Creswell, 2007). Similarly, Goulding (2005) states, the label grounded theory reflects that the theory is grounded in the words and actions of those individuals under study.

Since the origination of grounded theory, a range of strategies have emerged (Charmaz 2006; Goulding 2005; Strauss and Corbin 1998, 2015).

However, four main methodologies for grounded theory are used in academic research (Fernandez, 2012): (i) Glaser (1978) referred to as classical because of its loyalty to the primary ideas published in 1967, (ii) Strauss and Corbin (1990) qualitative data analysis (QDA) sometimes referred to as the Straussian grounded theory, (iii) constructivist grounded theory (Charmaz, 2001), and (iv) feminist grounded theory (Wuest, 1995). This study follows the constructivist, systematic design method detailed by Strauss and Corbin (1998, 2008 and 2015) and by Charmaz (2001). The authors seem to agree that the grounded theory approach should include the constant comparative method, linked with theoretical sampling and special coding procedures. This method is characterized by open coding, the development of concepts and categories based on their properties and dimensions; axial coding, the process of relating codes to each other, via a combination of inductive and deductive thinking; selective coding, the central category around which the final analysis will be based; and the development of a theory expressed in a series of propositions. The generation and development of concepts, categories and propositions is an iterative process. Therefore, data collection, analysis, and theory should stand in reciprocal relationship with each other.

Restatement of the Research Question

To be accredited, instructional programs in civil engineering must now set forth learning objectives that involve both technical and non-technical, assessment measures to determine how well the objectives are being met and plans for taking remedial action to address shortcomings revealed by the assessment (Radcliffe, Jolly, 2003). Since there appears to be a lack of unified guidance on the extent to which social sciences and humanities should be included in the undergraduate civil engineering curricula, the question to be answered in this study is – What modes of humanities and social thought should be incorporated into undergraduate civil engineering education?

Conceptual Framework for the Study

The conceptual framework for this research relied upon Vygotsky's concept of the zone of proximal development, the concept of scaffolding and Jean Lave and Etienne Wenger concepts of community of practice and peripheral participation. The framework for this research attempted to explicate the social and human challenges that engages civil engineering activities within the community of practice. The idea was to have civil engineering practice inform undergraduate engineering curricula by researching how practicing civil engineers engage with sociotechnical complexities. This revealed the characteristics that make undergraduate civil engineering education more human-centered and more inclusive.

Community of practice and legitimate peripheral participation

Jean Lave and Etienne Wenger developed the community of practice theory. According to the theory, it is within communities that learning occurs most effectively. Communities of practice are organized around a set of, "relationships among persons, activity, and world" (Lave and Wenger, 1991 p. 98). These collective learning relationships over time results in practices that reflect both the pursuit of the community and the social relations among the practitioners and between communities of practice. According to Lave and Wenger, communities of practice are organized around some area of knowledge, activity, shared ideas, commitments and tradition (Lave and Wenger, 1991; Wenger, 2004). The accumulated knowledge of the community is effectuated through praxis.

Initially people must join communities and learn at the periphery. The things they are involved in, the tasks they do, may be less significant to the community than that of more experienced engineers. As they become more competent, they become more involved in the main processes of the particular community. They move from legitimate peripheral participation into full participation (Lave and Wenger 1991; Wenger, 2010). According to Lave and Wenger (1991), peripherality, when legitimate, "suggests an opening, a way of gaining access to sources for understanding through growing involvement." (p. 37). Newcomers' legitimate peripherality provides them with a participatory way of learning. Newcomers participate in communities of practitioners and as they master the knowledge and skill required, newcomers move toward full participation. In this research framework, undergraduate civil engineering students are considered newcomers with legitimate peripherality. However, for them to become full participants in the community of civil engineers, newcomers must become familiar with the sociotechnical complexities that come with civil engineering practice.

Zone of proximal development and scaffolding

Lev Vygotsky defined the zone of proximal development as the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under guidance, or in collaboration with more capable peers (Vygotsky, 1978). His theoretical framework is built around the idea that social interaction plays a fundamental role in cognitive development. In the zone of proximal development, full development depends upon full social interaction between the learner and “more knowledgeable others. The zone of proximal development provides us with a tool through which the essential nature of civil engineering development can be understood. This framework allows us to take account of the cycles and maturation processes that civil engineering students have already completed and those processes that are currently in a state of formation, that are just beginning to mature and develop. Thus, the zone of proximal development permits us to delineate the undergraduate civil engineer’s immediate future and his/her “dynamic developmental state, allowing not only for what already has been achieved developmentally but also for what is in the course of maturing” (Vygotsky, 1978, p.87). For purposes of this framework, the Zone of Proximal Development comprise of the skills required to fully participate in and fulfill the requirements of a specific civil engineering classification. Its extent is the distance between a civil engineer’s ability to perform the duties of the classification with help and the ability to perform these duties independently. At each progressive stage, the engineer becomes more independent in performing his/her responsibility. As that independence grows the knowledge upper limits become closer and the Zone of Proximal Development narrows.

The cycle and maturation process are what I refer to as ‘scaffolding’. Though Vygotsky did not use the term scaffolding, the term evolved from the concept of the zone of proximal development. In its general sense, scaffolding refers to a variety of instructional techniques used to move students progressively toward stronger understanding and, ultimately, greater independence in the learning process. For civil engineers, scaffolding is the professional progression from student to executive. At each stage of this progression, the civil engineer’s independence of knowledge increases.

Conceptual model

The conceptual model, presented in Figure 3.1, builds on the work of Vygotsky, Lave and Wenger.

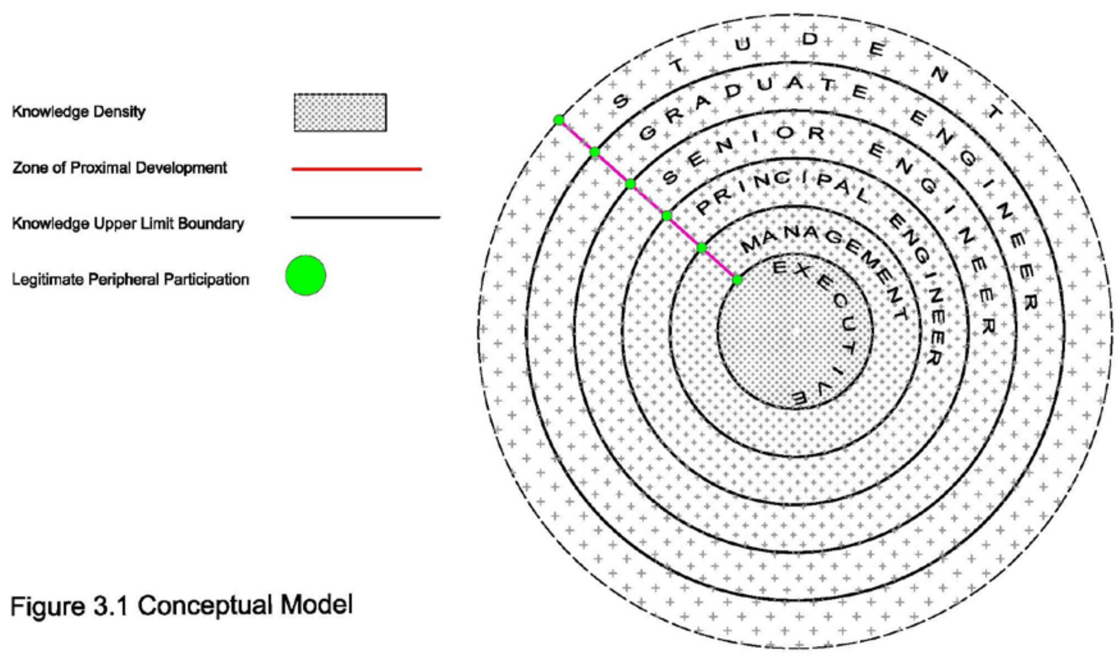

Figure 3.1 Conceptual Model

The model combines elements of Vygotsky's circle with Lave and Wenger's concepts of legitimate peripheral participation within a community of practice. This model uses the Civil Engineering Profession as a community of practice. It highlights the stages of professional progression for a civil engineer from student to the executive level. This research is concerned with contributing to the discourse on the Knowledge Upper Limit Boundary of undergraduate civil engineering students and their peripheral Participation in the graduate engineer classification.

After graduation, new civil engineering graduates initially will be employed to fulfill a basic technical position within an engineering firm or agency. The title they are given may be assistant engineer, or graduate engineer. As a new civil engineer, the individual's primary responsibility is to learn and drawing lessons from the work that they are assigned to do. At the beginning, they will be given a variety of less technically demanding tasks in support of a senior civil engineer.

The graduate engineer's ability to accept more complex and demanding tasks and to carry out those tasks successfully is considered for advancement. In some organizations, the graduate engineer must be licensed to qualify for promotion to senior engineer classification. The senior engineer generally is responsible for coordinating the work of a small number of graduate and assistant engineers and auxiliary personnel such as technicians.

If the senior engineer elects to advance professionally, he or she may be given a title such as principal engineer. At that point, the civil engineer will quickly find that their work rapidly forces them to specialize in certain aspects of their chosen civil engineering specialty. He or she must also undertake more administrative work such as the preparation of reports on the activities of subordinates and must schedule individual workloads. Additionally, he or she may be involved in developing schedules and budgets for the work he or she supervises.

Career growth includes the opportunity for project team management, supervisory and management positions. As a civil engineer gains experience, they will be assigned projects with greater and greater responsibility. Some civil engineers may decide to forego direct technical activity in engineering for the challenge of management activities. At this point, a civil engineer electing a career in management assumes more responsibility for coordinating and arranging the activities of a group of colleagues. He or she is engaged more frequently in making decisions on non-technical matters involving the allocation of personnel to specific tasks or in choosing objectives for the organization. He or she may assume successive titles such as engineering superintendent, branch chief, engineering manager, or division chief.

If the engineer reaches the executive level of management, the title may be director or president. The engineer who rises to this position may assume more comprehensive administration duties. The executive engineer is expected to provide strategic direction, to distribute operations, demonstrate vision, experience and maturity. Executive engineers pay proper attention to every process of project completion and guide the work accordingly.

Knowledge upper limit boundary. Knowledge Upper Limit Boundary is the outer limit of the Zone of Proximal Development for a certain job classification. This is the level of maximum expected development for a civil engineering classification. This upper limit is delineated by the complexity and demands of tasks that an engineer is expended to perform at each stage of their career. It marks the limit of responsibility and autonomy for a civil engineer of a specific classification.

At each stage, the engineer progresses through a zone of proximal development to the upper limit boundary of knowledge. At the upper limit boundary, the engineer begins peripheral participation into a more advanced stage of development. At each progressive upper limit, he or she has a higher command of the knowledge, practices, and resources within the community of practice (Lave and Wenger, 1991, p. 37).

Legitimate peripheral participation. The civil engineer enters each stage of his/her career by a process of participation that is at first legitimately peripheral but increases gradually in engagement and complexity. Legitimate Peripheral Participation is the edification of the engineer by observing, listening, questioning and reflecting. Peripheral participation is not immutable but constantly changing with the engineer's increasing independent competence. Over time, peripherality evolves into full participation, or a level at which an engineer has a more key, higher stake, or impactful role in the community of civil engineering.

Knowledge Density. Knowledge Density measure is based on the number of separate fragments of information relative to the taxonomy of the job. What an engineer is expected to know to fully participate in a civil engineering job classification is referred to in this paper as 'knowledge density'. As the engineer progresses in the community of practice and advances from a student towards an executive, the complexities of their tasks are expected to increase. As a result, the fragments of information the engineer grapples with will increase and thus, the engineer's knowledge density is expected to increase as he or she progresses from a student to the executive position.

Research Design

A theoretical model represented in Figure 3.2 was used for this study.

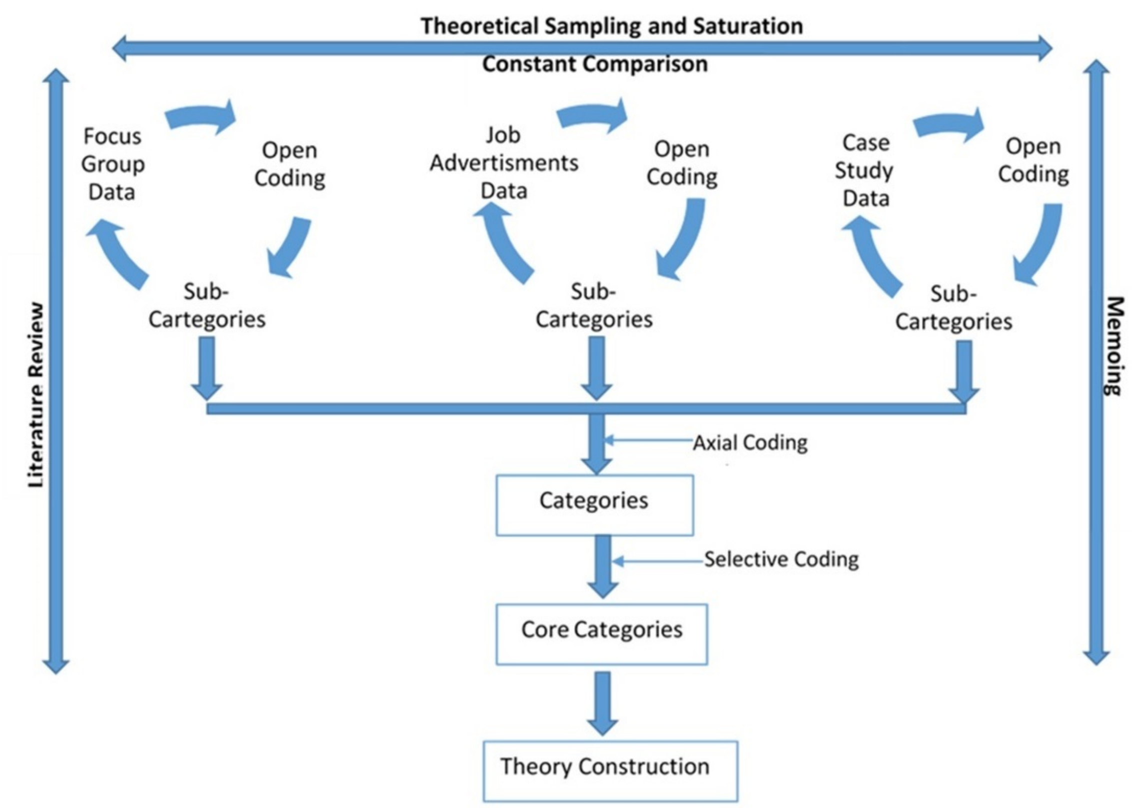

Figure3.2 . Research Flowchart. Analysis process of grounded theory research

The purpose of Figure 3.2 is to outline a process of theory building that linked the research methods to theory. Literature review was an integral part of this study's methodology. It was implemented throughout the theory building process. Strauss and Corbin support this approach and state:

> "The literature can be used as secondary sources of data. Research publications often include quoted materials from interviews and field notes and these quotations can be used as secondary sources of data for your own purposes. The publications may also include descriptive materials concerning events, actions, settings, and actors' perspectives, that can be used as data" (1990, p. 52).

During this process, issues arose that led to identification of a need for additional literature searches. According to (Eisenhardt, 1989), tying the emergent theory to literature enhances the internal validity, generalizability, and theoretical level.

I looked to Egan (2000) for a description of data collection and analysis for this study. The process started with purposeful data source selection, involving the locations and identification of potential data sources associated with the research question. Later in this chapter, I discuss the selected sources of data for this research. Data source selection was followed by ongoing data collection from the various sources as a way to expose variation and a way to establish conceptual frameworks. Through theoretical sampling, concepts became more specific and methods of inquiry more structured. Concepts are the basic units of analysis. A theorist works with conceptualizations of data and not the actual data per se. Data collection was also informed by literature reviews and aided by persistent memoing of the researcher’s conceptual ideas.

Data analysis, according to Egan (2002), is undertaken in response to ongoing data collection and comparison. This study used a process of analysis that started with coding the first set of data. This was followed by an ongoing application of codes and necessary changes in sites or respondents. This research process included comparisons and revisions of the codes as needed, checking for emerging categories, and forming category sets. Subsequently, applications of the categories and their properties were conducted to assess their levels of needed elaboration. Data were collected and analyzed until saturation was achieved. Theoretical saturation is defined later in this chapter. Upon achieving saturation, selective coding was performed in support of theory construction. Axial and selective coding and theory construction are also discussed later in the chapter. Like in the data collection phase, literature review and memoing were also conducted throughout the analysis phase. Memos were written to describe and clarify the analytical rationale for the research process.

Theoretical Sampling

Glaser and Strauss (1967) defined theoretical sampling as: “the process of data collection for generating theory whereby the analyst jointly collects, codes and analyses his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges” (p.45). When research begins, the researcher brings to it some idea of the phenomenon he or she wants to study. Based on this knowledge, groups of individuals, or representative of that phenomenon can be selected for study (Strauss and

Corbin, 2008, 2015). Theoretical sampling is salient in achieving representativeness and consistency of concepts (Strauss and Corbin, 2008, 2015). The intent is to build a theoretical explanation by specifying phenomena, in terms of the conditions that give rise to them. This research sought to study the modes of humanities and social thought that informs entry level civil engineers' work. Therefore, I intended to sample incidents, events, and happenings that denote the work of civil engineers, the conditions that facilitate, interrupt, or prevent their work, the action/interaction by which it is expressed, and the consequences that result. By capturing the details of entry-level civil engineers’ work, I hoped to extrapolate the modes of humanities and social thought within.

The purpose of this sampling is to refine ideas and explicate robust theoretical categories that accumulate relevance and applicable (Breckenridge and Jones 2009) to undergraduate civil engineering education, the peripheral of entry-level civil engineering practice. Consistency is needed as concepts earn their way into the study by showing their relationship to the phenomenon under investigation (Corbin and Strauss, 2015). I accomplish this by carefully noting the qualifiers, thus giving specificity to the concepts.

Data Collection Narration

In accordance with grounded theory principles, the approach to collecting data in this study presumed that ‘all is data’ (Glaser, 2001). This methodology used both quantitative and qualitative data to find out what is really going on (Glaser and Strauss, 1967) in respect of the studied phenomenon. Using the prescribed method of collecting and analyzing data on a ‘zigzag basis’ (Strauss and Corbin, 1998, 2008), this research proposed to collect some data, explore the data through initial open coding, established tentative linkages between categories, and then returned to the field to collect further data.

For the purposes of this study, data collection sources involved focus group interview, case study, job descriptions, and literature view. The data I collected was progressively focused and informed by the emerging theory (Glaser and Strauss 1967). By using various sources and methods of data collection, I triangulated, that is, I was better able to accurately, increase fidelity of interpretation of the data (Glesne and Peshkin, 1992). In proposing a procedure for the research, I trod lightly between satisfying the criteria for grounded theory and allowing myself procedural flexibility to address the contingencies of the actual research. The following text provides details and explains the use of the various data collection sources and methods.

Job advertisements. Job advertisements are the first source of data for this study. The job advertisements included job descriptions, duties, responsibilities, required attributes and skills. This dataset included job advertisements in all disciplines of civil engineering from all fifty States. It included advertisements from federal, state and local governments, engineering news-record (ENR) 500 and non-ENR 500 firms. According to the Bureau of Labor Statistics, civil engineering job change from 2016 to 2026 is approximately 32,200 jobs. That calculates to approximately 268 new jobs per month. One-Hundred and ninety-two job advertisements for the month of October 2018 were collected for analysis. This sample size provides a large confidence level but that is not to say it achieved saturation. It simply meant the data sufficiently represented the population of entry-level civil engineering jobs. This data was to become part of the inductive argument to establish the strength of the claims.

There is a strong argument that the collection of job advertisements could produce a measurable and comparable set of research data (Harper, 2012; (Litecky, Arnett and Prabhakar, 2004). The preliminary focus here was to adopt a qualitative approach by using content analysis of job advertisements, triangulated with other data collection methods to ascertain the knowledge and skills requirements for a modern civil engineer. Content analysis was a commonly used descriptive technique for analyzing the content of the documents to discover features and patterns (Neuman, 2006). “Content analysis of job advertisements is a well-established method of researching employment requirements in a particular sector” (Orme, 2008, p. 620) and is very useful in reflecting the demands of employers, employment opportunities and emerging trends in the employment market.

“The market for civil engineering services is not likely to diminish in the 21st century; the only questions are what role civil engineers will play in determining the scope of their contributions and the market value for these services” (Stouffer, Russell and Oliva, 2004, p. 3). Civil engineers work in various sub-disciplines, jurisdictions, industries and for various employers. These employment demographics are particular in the way problems are approached and solved. As civil engineering is a professional discipline which purpose is to solve problems related to the built and natural environment, the scope of engineers' contribution and the value of their services are dependent on the effectiveness and efficiency with which they can solve problems within the specific specialism, industry, jurisdiction or organization.

When engineers apply for civil engineering jobs, they are likely to apply for a role or graduate scheme in a particular specialism or industry. Larger employers usually hire graduates into a specialist division or business, while smaller organizations often focus on one or two specialisms in total. Whichever sector an engineer chooses, however, the nature of the job will differ depending on the type of employer. The following tables in this section are meant to demonstrate the levels at which these employment demographics are represented in the data. It is important that the data collection capture these demographics in order to analyze the variations in entry-level engineers working experiences. Advertised positions were grouped into a number of categories according to the requirements listed by employers. Table 3.1 presents these categories.

Table 3.1 Considered position titles in ads

Position Title	N	P (%)
Entry level Engineer	69	36.0
Engineer in Training	39	20.3
Civil Engineer	33	17.0
Graduate Engineer	20	10.4
Junior Engineer	16	8.3
Engineering Intern	11	6.0
Engineering Technician	4	2.0

Although advertisements analyzed listed jobs in the category of entry-level civil engineering, only 36% included the term “entry level”. The other 64% provided a detailed description of a job suiting an entry-level civil engineer without actually mentioning the category of entry level.

Every year, Engineering News-Record (ENR) publishes the 500 largest U.S.-based designs firms, both publicly and privately held, based on design-specific revenue. Table 3.2 divides private-sector jobs into ENR 500 and Non-ENR 500 employers. An equal number of jobs were collected from ENR 500 and Non-ENR 500 firms.

Table 3.2 Jobs by employer group

Employer Group	N	P (%)
Federal Government	**7**	**4.0**
State Government	**16**	**8.0**
Local Government	**15**	**8.0**
ENR 500	**77**	**40.0**
Non-ENR 500	**77**	**40.0**

Advertisements were grouped into civil engineering disciplines according to the requirements listed by employers. Table 3.3 presents these disciplines.

Table 3.3 Jobs by civil engineering disciplines

Disciplines	N	P (%)
General Civil Engineering	85	44.3
Transportation Engineering	43	22.4
Environmental Engineering	19	9.9
Water Resources	11	5.7
Structural Engineering	9	4.7
Geotechnical Engineering	9	4.7
Construction	6	3.0
Land Surveying	3	1.6
Mining	3	1.6
Coastal Engineering	3	1.6
Research	1	0.5

The most frequently mentioned discipline was General Civil Engineering at 44.3%. The next most often mentioned is discipline was Transportation Engineering at 22.4%, followed by Environmental Engineering at approximately 10%.

Table 3.4 presents the number of job advertisements that were collected from each State. More jobs were collected from the more populated States of

Table 3.4 Number of job advertisements per State

States	Number of Advertisements	States	Number of Advertisements
Alabama	3	Montana	2
Alaska	1	Nebraska	2
Arizona	5	Nevada	2
Arkansas	2	New Hampshire	2
California	11	New Jersey	5
Colorado	4	New Mexico	5
Connecticut	1	New York	11
Delaware	3	North Carolina	4
Florida	4	North Dakota	4
Georgia	5	Ohio	2
Hawaii	2	Oklahoma	2
Idaho	3	Oregon	4
Illinois	2	Pennsylvania	5
Indiana	3	Rhode Island	2
Iowa	4	South Carolina	3
Kansas	2	South Dakota	3
Kentucky	4	Tennessee	4
Louisiana	2	Texas	12
Maine	6	Utah	3
Maryland	6	Vermont	2
Massachusetts	2	Virginia	4
Michigan	1	Washington	4
Minnesota	10	West Virginia	4
Mississippi	3	Wisconsin	4
Missouri	5	Wyoming	3

California, New York and Texas. The number of jobs collected from some States, (for example, Minnesota and Florida) are not representative of their populations due to the number or diversity of available jobs.

Table 3.5 indicates that Engineer and Professional service was the industry with the most job advertisements, having 125 out of 192 ads (65.1%).

Table 3.5 Jobs by Industry

Industries	N	P (%)
Federal Government	7	3.6
State and Local Government	31	16.1
Engineer and Professional services	125	65.1
Construction	6	3.1
Mining	3	1.6
Utilities	12	6.3
Manufacturing	3	1.6
Energy	4	2.1
Academia	1	0.5

This was followed by State and Local Governments at 16.1%.

Focus group interviews. After initiating categories, moving to a second data collection source provided opportunities to refine and increase the scope of the emerging theory (Breckenridge, 2010). The second data source was predetermined because there appeared to be some minimized differences between the two sources. Focus group is a form of group interview that capitalizes on communication between research participants to generate data (O'Connor, 2012). The idea behind the focus group method is that group processes can help people to explore and clarify their views in ways that would be less easily accessible in other methods (Kitzinger,1994). According to Creswell (1994), a major strength of qualitative research such as focus group interviews is the propensity to yield candid, sometimes insightful, information. Powell and Single (1996) concludes that, the advantage of focus groups is the ability to help the researcher in identifying quickly a full range of perspectives held by respondents.

The source for the focus group study was Dunwoody College of Technology. At the time of the focus group, Dunwoody College of Technology was expanding its academic program to include civil engineering. The new degree is meant to combine academic coursework with real-world applications. I was tasked with developing a curriculum map and curriculum flowchart; however, the focus group was facilitated by Dunwoody staff. I used the transcripts from a focus group study that aimed to answer the question of engineering education for 21st century civil engineering practice. The focus group comprised of twenty-six civil engineers from the private sector, government and academia. Participants were requested to respond to a series of questions and to participate in discussions that were generated by the questions and the responses to them. The principle questions asked were as follows:

What does a Dunwoody Civil Engineer look like in the Profession?

1. Objectives for the Program - measurable, mechanism for measurement and timed.
2. Characteristics of a Dunwoody Civil Engineer as a Professional within the Profession.
    - 2a. A brainstorming session obtained objectives for the program that would be measurable, have a mechanism for

measurement and a defined frequency of assessment.

2b. This brainstorming led to characteristics of a Dunwoody Civil Engineer as a professional within the profession.

What does a Dunwoody Civil Engineer need to Know?

1. Components within the Curriculum.

2. Items that make a Dunwoody Civil Engineer unique.

Through affinity mapping, the group worked through the development of desirable programmatic outcomes, identified components within the curriculum and items that would make a Dunwoody civil engineer unique.

The questions in the study were intended to reveal what ought to be the motives of a 21st century civil engineering curriculum. The findings of the focus group caused me to conclude that the discovery of modes of humanities and social thought in civil engineering required inductive and deductive analysis. The answer lay not in what the key informants surmised but in the actual work performed by entry-level civil engineers. This way the research data was actual and grounded the theory in data (Glaser and Strauss, 1967). The focus group study serviced as a base from which open coding began. For additional data, I then looked to a Case Study to capture entry-level civil engineers on the job practical experiences.

Case study. This research used case study as another data source, a way of binding the data, and a method of analysis. I chose the Metro Transit, a division of the Metropolitan Council as the case study. The case reflected the real-life experiences of entry-level engineers at the Metro Transit. Entry-level engineers and interns were hired to work on project teams in support of senior staff. They played support roles in every aspect of a project and were vital to the delivery of projects. I also used documents from Metro Transit such as policy statements, guidelines, procedures, etc., as supporting data.

Qualitative case study is an approach to research that facilitates exploration of a phenomenon within its context using a variety of data sources (Baxter and Jack, 2008). Case study can embrace quantitative and qualitative data and multiple research paradigms. Thus, case study research can contribute in a holistic way to all phases of theory development (Dooley, 2002). Case studies typically rely on multiple data sources, which provide as complete a picture as possible, and enhances credibility (Neale, Thapa and Boyce, 2006; Patton, 1990; Yin, 2003). Therefore, the sources of information for this study included documentation, archival records and physical artifacts. The documents from which I collected data included supervisors' justifications for the positions, business cases for the positions, job interview questions and project files. Within the case, I also used transcripts from intern exit interview to collect additional data. Exit interviews were semi-structured presentations with question sessions of interns who had completed their internship. I gathered data and make the meanings of the participants explicit. I then continue to add individuals to the sample until reaching theoretical saturation. That is, I was no longer learning anything new.

Literature. The place of the literature review in a grounded theory study is an issue of considerable debate in the research community (McGhee, Marland

and Atkinson, 2007). However, Strauss and Corbin (1998 and 2015) update to the original grounded theory approach to literature is suitable for this study, recognizing that “the researcher brings to the inquiry considerable background in professional and disciplinary literature” (Glaser and Strauss, 1967, p. 49). (Strauss and Corbin, 1998 and 2015) argue that literature is useful as early as initiation of the research, which includes the selection of an area of inquiry and suitable sites for the study. As the study progresses literature becomes an effective analytic tool to stimulate thinking (Hickey, 1997) and “to [prepare] minds during the interplay with the data” (Strauss and Corbin, 1998, p. 47).

One of the central principles of grounded theory, however, is the idea of not using the literature as a source of concepts (Andrew, 2006). Rather it is viewed simply as more data to be synthesized and integrated into the emerging theory (Glaser 1998) and, as long as the researcher "maintain[s] an attitude of skepticism" (Strauss and Corbin, 1990, p.45). This was my guiding principle as I gathered the basic elements of grounded theory analysis - the identification of concepts – that, I grouped to form categories. During this process, issues arose that required a literature search. As such, literature review was an ongoing part of the process whereby the theoretical framework evolved. The reflexive use of my professional experience was instrumental in the processes of developing the research and for guiding the literature reviews. My professional experiences guided me to literature that discusses the concepts that are embodied in this study. The articles were selected because they provided insight into the relationship between engineering education and engineering practice, the methods used to measure the relationship, and the realities of conducting this study.

Data Analysis

Consistent with the tenets of grounded theory, constant comparative method was employed in this study. Analysis was necessary at the outset of the study because it directed the next set of data to be collected. In this dissertation, I deployed the systemic and sequential procedures of data collection and analysis. The qualitative analysis approach I used is a form of grounded theory by Strauss and Corbin involving the systematic coding of the data around emerging concepts.

The aim of the analysis was to build an integrated framework upon which to base plausible assertions about humanities and social science in entry-level civil engineering education. Strauss and Corbin (1998) describe the procedure as beginning with open coding – “process through which concepts are identified and their properties and dimensions are discovered in data” (p.101); followed by axial coding – creating subcategories and associating these with “properties and dimensions” (p.123) and thirdly, selective coding – “integrating and refining the theory” (p.143) by using categories and their associations with subcategories to create a type of case study of a particular phenomenon.

Memos were used to capture theory development. Theoretical memos were written about codes and their relationships with other codes. In addition, existing literature integrated the theory through the coding process. Through this iterative process of coding and combined with constant comparison and theoretical sampling, descriptive data systematically abstracted the theoretical explanations and assertions.

My approach to this research, based on the premise that the distinction between open coding and axial coding, is for explanatory purposes only (Corbin and Strauss, 2008). Open coding and data collections are integrated activities thus, the data collection and open coding occurred simultaneously and continue until I selected all the main categories. During open coding, concepts were compared against others for similarities and differences; they were also conceptually labeled. In this way, conceptually similar incidents were grouped together to form categories and their subcategories.

I automatically integrated open and axial coding procedures when working with the data. I coded axially based on the patterns that emerged during open coding. For this reason and to that end, the open coding subcategories were organized together into six preset axial subcategories described by Strauss and Corbin (1998) and included: (a) categories (b) causal conditions, (c) contextual conditions, (d) intervening conditions, (e) strategies, and (f) consequences.

Causal conditions refer to the factors that lead to the occurrence of the phenomenon, the subject under study, or the central idea. The causal conditions specify the phenomenon with respect to incidents or occurrences that result in their appearance or development. Intervening conditions refer to the many factors that can influence the phenomena. They are those conditions that "mitigate or otherwise impact causal conditions on phenomena" (Strauss & Corbin, 1998, p. 131). Second, contextual condition is the specific set of characteristics in which the phenomenon is embedded. They are the “specific set of conditions (patterns of conditions) that intersect dimensionally at this time and place to create a set of circumstances or problems to which persons respond through actions/interactions” (p. 132). Third, intervening strategies are the broad and general conditions that influence action/interaction strategies. These comprise, for instance, time, space, culture, socioeconomic status, technological status, career, history, and individual biography (Vollstedt and Rezat, 2019, p.88). Actions and interactions are processes, facilitated, and constrained under given conditions. Finally, consequences refer to the outcome of the phenomena as they are engaged through action and interaction.

Causal conditions contribute to the occurrence or development of the phenomenon. Under contextual conditions are included particularly time, place and duration. Moreover, among intervening conditions we find the social, political and cultural environment and the individual biography. Actions and interactions lead to particular consequences.

Data Aggregation

Appendix A is comprised of three sections – A1, A2 and A3 – that depicts coding for the three sources of data, Job Advertisements, Focus Group Interview and Case Study respectively. Events, actions, happenings, etc. that denote the causal conditions, context conditions, action/interaction strategies or consequences of a potential phenomenon were considered to be incidents. Incidents are indicators of a potential phenomenon. As I encountered incidents, which when compared to the first appear to resemble the same concept, they were conceptually labeled.

Concepts found to pertain to the same phenomenon were grouped to form subcategories. Subcategories are slightly higher levels of abstraction than the incidents themselves that allows the application of a name (label). The strategic process of moving from incidents to abstract categories was a matter of identifying or discovering concepts that capture an idea or phenomenon described by my notes. Every concept brought into this study in the research process was first considered provisional and earned its way into the theory by repeatedly being present in the data sources.

Open coding

Open coding involves "breaking down, examining, comparing, conceptualizing, and categorizing data" (Strauss and Corbin, 1990, p. 61). Open coding is the initial stage in analyzing data whereby data are coded for all possibilities (Glaser 1978). During open coding, data were analyzed line-by-line, by sentence, paragraph, and by a holistic analysis of an entire document in order to maximize theoretical coverage. Open coding means code everything for everything; however, I needed to be cautious about conceptual description taking precedence over theorizing (Stern, 2007). I heeded to the recommendation for overcoming mere conceptual descriptions by asking important questions of the data: what is this data a study of; what category or property of a category does this incident indicate; and what is actually happening in the data? Asking these questioning whiles coding the data enhanced analytic abstraction of theoretical categories and the relationships between them (Glaser 1978). As shown in

Figure 3.3, data were sequentially collected from each data source (focus group, job advertisement and case study). Each concept within the data was open

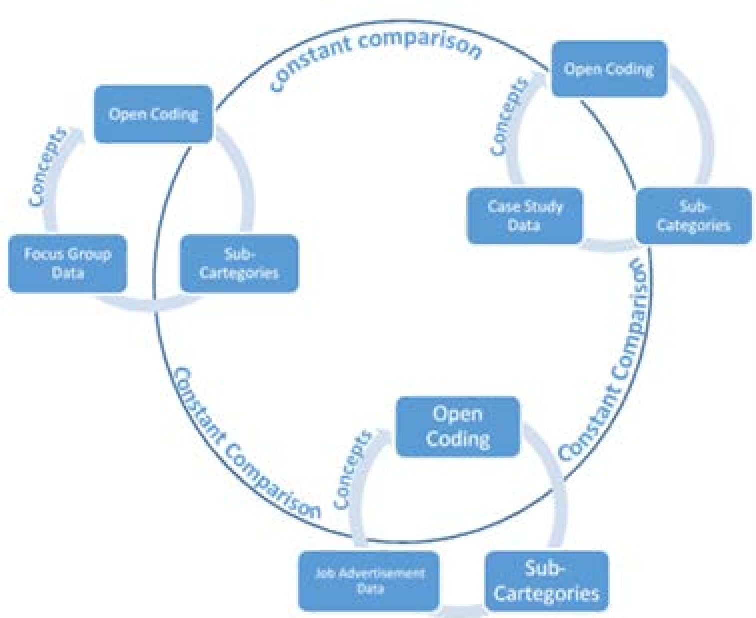

Figure 3.3. Strategy for Open Coding

coded and then grouped into sub-categories. The coding and grouping processes involved constant inter-data-source and intra-data-source comparison of data, concepts, sub-categories.

Job Advertisements. Through the analysis of job advertisements, this study aimed to identify what hiring agencies required in terms of civil engineering knowledge, skills, competencies and personal characteristics. One-hundred and ninety-two entry-level civil engineering job advertisements were used for this study. Concepts within the job advertisements were first coded into subcategories. Line-by-line coding was first employed to create concepts present in the data. This process evolved simultaneously searching for new concepts and creating the appropriate subcategories while also attending to the continued development of existing subcategories. As the list of subcategories grew, it became necessary to consider the relationships between the developed subcategories, and to refine the subcategory list accordingly.

At this stage, general concepts emerged that were used to explore the relationships between emerging subcategories to form categories. In the axial coding process, I related categories to their subcategories, and these relationships were tested against the data. The concepts that emerged from the analyses were repeatedly compared with the data to ensure their validity. Also, any links between categories that emerged were kept only if they could be repeatedly validated from the data. At the end of that stage of the research, I had identified 81-subcategories as shown in Appendix A1 and the emergence of seven categories: Context Sensitive Design, Environmental Stewardship; Communication, Project Economics Project Management, Rules, and Ethical Conduct. The categories that emerged were strong in Action/Interaction Strategies Condition, moderate in Causal Condition and weak in Context and Convening Conditions.

Focus Group. Further sampling was directed by a Focus Group on twenty-first century civil engineering curriculum. The process of adding and reconfiguring subcategories continued by analyzing new data and concepts. Memos were used to compare new incidents from the Focus Group with the findings from the job descriptions. Incidents that related a common concept to those from the job descriptions were grouped together in their respective subcategories. This was an important step towards achieving theoretical saturation. By comparing each concept in turn with all other concepts, further commonalities were found which formed three additional subcategories, thus, adding to the strength of the coding paradigm. Appendix A2 is a tabulation of the additional concepts and subcategories that were coded from the Focus Group study.

Case Study. A study of the Metro Transit's entry-level civil engineers and interns revealed rich and descriptive data. For the Case Study, the coding exercise included an analysis of elements of work that were assigned to entry level civil engineers and civil engineering interns or elements of work in which they participated. The difference in work between the two job classifications, it appeared, is in the level of explanations of assignments and review of work. However, both classifications had full autonomy in the ways they perform their assignments.

I evaluated the projects in which six engineers and five engineering interns participated between the periods of 2007 to 2019. The contents of the project files and supporting documents were coded for emerging concepts. Appendix A3 is a tabulation of the concepts and subcategories that were coded in the Case Study. Civil engineering projects and project activities are governed by rules, processes, procedures and organizational policies. Therefore, in addition to the project files, I also examined the various guiding documents for additional concepts. Also, Appendix B is a summary of the projects that were used as examples in this study. These projects were used to help explain the circumstances, which placed the incidents into their respective paradigms. Projects were selected because they were likely to contribute to the differentiation, elaboration, consolidation, and validation of categories in terms of their properties, their dimensions, or their interrelations.

Furthermore, memos were used to compare emerging concepts from the Case Study to concepts and subcategories from the previous data sources. Concepts that were similar to those from the previous analyses were grouped together in their respective subcategories. This again was an important step towards achieving theoretical saturation. Likewise, by comparing each concept in turn with all other concepts, further commonalities were found which formed 28 additional subcategories.

These additional subcategories strengthened the coding paradigm, in particular the context and intervening conditions. It became apparent after line-by-line coding the project documents of the first nine entry-level engineers that many of the same concepts were being to emerge, albeit in various incarnations. In addition, fewer codes were being developed with the review of each additional engineer's project files. Because of this repetition of concepts as well as the volume and depth of the data from the work of the first nine engineers, I decided to make use of the projects from a 10th and 11th engineers as test cases for data saturation or informational redundancy. The analysis of the line-by-line coding of the 10th and 11th engineers' work revealed no new categories were emerging. No additional codes for newly discovered concepts were created during the coding of these engineers' work and theoretical saturation was achieved.

Theoretical Saturation

Theoretical saturation is the point at which the researcher stops sampling, whereby categories and their properties are considered sufficiently dense and data collection no longer generates new leads (Glaser and Strauss 1967; Bogdan and Biklen, 2006; Strauss and Corbin, 2008). Glaser and Strauss (1967) defines sufficiently dense as a state of interchangeability whereby empirically different incidents indicate the same concept. While most authors agree that saturation is achieved when no new insights are obtained, no new concepts are identified, and no issues arise regarding a category of data, there are no definitive rules for determining saturation (Hyde, 2003).

However, the perspectives on saturation presented by authors, Strauss, Corbin and Charmaz provided me with some direction for operationalizing the concept. Figure 3.4 is a conceptual representation of the strategy that I propose to implement for this study to achieve theoretical saturation. I define theoretical

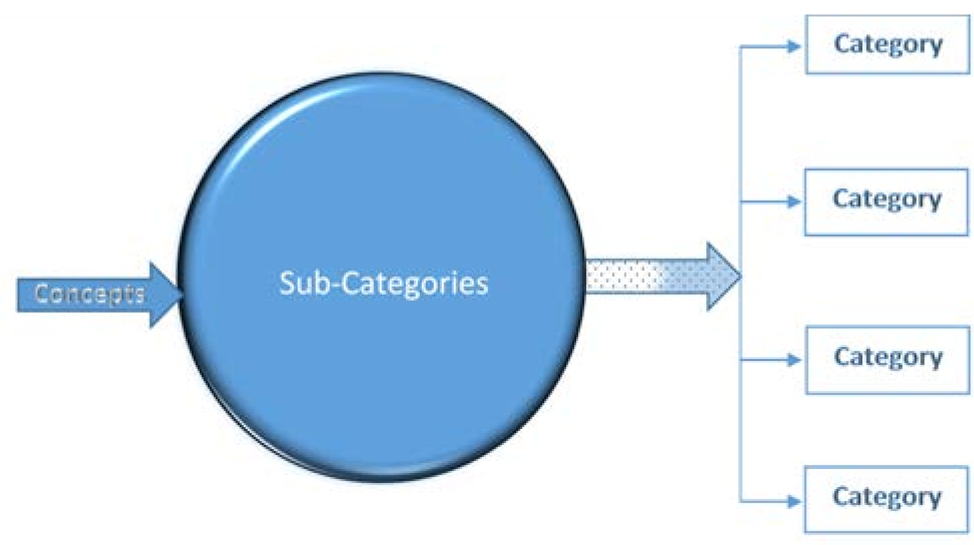

Figure 3.4. Saturation Strategy. This is the process used for achieving saturation.

saturation for this research as a point when the sub-categories do not create new categories and do not add insight into the existing categories.

Axial coding

Axial Coding refers to the analytic activity for "making connections between a category and its sub-categories" (Strauss and Corbin, 1990, p. 97) via a combination of inductive and deductive thinking. The aim is to strategically reassemble data that were split or fractured during the open Coding process (Strauss and Corbin, 1998). It is a vital part of the process, which adds depth and structure to existing categories. To help clarify the point of axial coding, Strauss and Corbin (1998) describe an organizational scheme they call a ‘paradigm’. “Through the "coding paradigm" of conditions, context, strategies (action/interaction), and consequences, subcategories are related to a category (Strauss and Corbin, 1990, p.13). When axial coding, my focus was on specifying a category in terms of the preconditions that gave rise to it; the context in which it was embedded; the action/interactional strategies by which it was handled, managed, carried out; and the consequences of those strategies. Table 3.6 depicts a general example of my strategy for axial coding base on the paradigm model.

<table>
<tr><th colspan="3">**Table3.6** Axial Coding based on the Paradigm Model</th></tr>
<tr><th>Sub-Categories</th><th>Coding Paradigm</th><th>Categories</th></tr>
<tr><td>Sub-category 1</td><td rowspan="3">Causal Conditions</td><td rowspan="15">**Phenomenon (Category)**</td></tr>
<tr><td>Sub-category 2</td></tr>
<tr><td>Sub-category 3</td></tr>
<tr><td>Sub-category 4</td><td rowspan="3">Context Condition</td></tr>
<tr><td>Sub-category 5</td></tr>
<tr><td>Sub-category 6</td></tr>
<tr><td>Sub-category 7</td><td rowspan="3">Intervening Condition</td></tr>
<tr><td>Sub-category 8</td></tr>
<tr><td>Sub-category 9</td></tr>
<tr><td>Sub-category 10</td><td rowspan="3">Action/Interaction
Strategies</td></tr>
<tr><td>Sub-category 11</td></tr>
<tr><td>Sub-category 12</td></tr>
<tr><td>Sub-category 13</td><td rowspan="3">Consequences</td></tr>
<tr><td>Sub-category 14</td></tr>
<tr><td>Sub-category 15</td></tr>
</table>

Theoretical sensitivity played an important part in this stage of the research. Corbin and Strauss (2015) describe sensitivity as “having insights as well as being tuned into and being able to pick up on relevant issues, events, and happenings during collection and analysis of the data” (p. 78). My experience as a practicing civil engineer was instrumental in guiding me through the coding process. My experience and literature reviews were especially helpful for labeling the various subcategories and for working out the links between a category and its subcategories. My first step was to separate all subcategories into similar themes. I then placed them into respective coding paradigms based on the themes. For example, if the theme was ‘communication’, then the coding paradigms were the causes, contexts, interventions, strategies and consequences of communication. After initially placing the subcategories into the coding paradigms of their various categories, I then evaluated the incidents within the categories for completeness. Through the use of literature reviews, I also compared the subcategories within the categories for content. That sometimes required me to revisit the data sources for missed information that would corroborate and strengthen the evidence of a theme. This process also led me to rearrange data for better fit and discovered that some subcategories could be used in multiple coding paradigms within a theme and in multiple themes. When enough data confirmed a theme, that theme was then be labeled as an appropriate category, for example, communication was categorized and labeled as ‘effective communication’ based on the evidence of the combined data.

In this research, categories that emerged from the coding process were structured and reported via action diagram and tables. Action diagrams are simplified version of the paradigm model that help to graphically represent the categories that emerged. At this point in the research process, I had achieved theoretical saturation.

Selective coding

Selective coding is the process by which all categories are unified around a ‘core’ category, and categories that need further explication are filled-in with descriptive detail (Strauss and Corbin, 2008, 2015). This definition is based on the belief that there is a storyline around which everything else is draped. Figure 3.5 portrays the process by which selective coding is done.

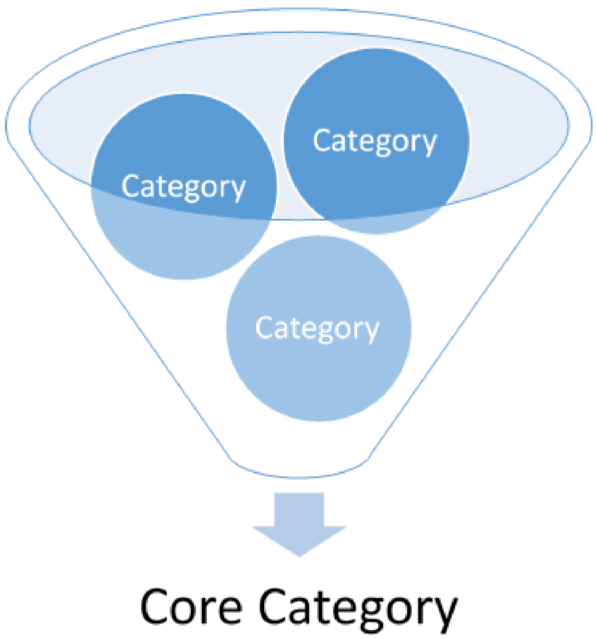

Figure 3.5 . Selective Coding.

The core category represents the central phenomenon of the study (Strauss and Corbin, 2008, 2015). For purposes of this study, it represented a phenomenon from which assertions are drawn. This phenomenon is representative of the categories of which it comprises. This was a critical first step as I contemplated the write-up for the central point, or storyline. I used the data to guide my thoughts towards the storyline and to think about that storyline. The selective coding process also helped to balance the description, analysis, and interpretation of the data. That meant that I had to make shore that a sequence of prerequisites was achieved as incidents formed concepts of subcategories and as subcategories combined to form categories and also, as the categories formed a core-category. This is what (Strauss and Corbin, 2008, 2015) referred to as a hierarchical structure.

The identification of categories involved the production of a hierarchical structure, which showed tentative relationships between factors identified from the systematic procedures of grounded theory described as previously described. A hierarchical structure was derived during the open and axial stages of analysis. Categories and subcategories were used to assist in coding data obtained in the research around the core category identified as, 'Sustainable Infrastructure Projects'. Categories and subcategories were identified and positioned based on their relationship and conceptual linkage to the core category (Strauss and Corbin, 2008, 2015).

Theory Construction

Although most often referred to as an inductive methodology, grounded theory analysis does maintain a crucial and subtle balance between inductive and deductive logic, whereby data collection and analysis become increasingly deductive as the theory is delimited to the core category (Strauss and Corbin, 2008, 2015). Through a process of inductive reasoning as outlined in this chapter and by deductive reasoning, I was able to reveal modes of humanities and social thought that are necessary for entry-level civil engineer. By deductive reasoning, I linked data to any emerging modes of humanities and social thought. The process of deductive reasoning started out with a general thought, and examined the possibilities to reach a specific, logical conclusion. Stephen Toulmin, a British philosopher, provides a model by which practical deductive reasoning can occur. His argument structure is presented in the example argument that is diagrammatic representation in Fig. 3.6.

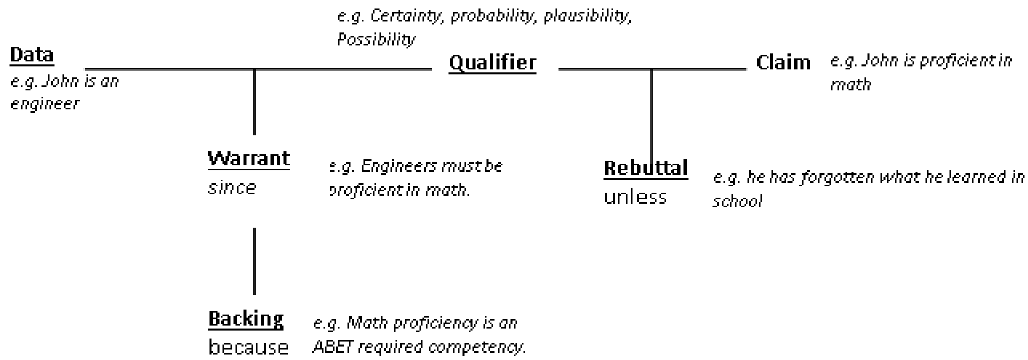

Figure 3.6 . Theoretical model of argumentation. Base on Toulmin's Model

Toulmin's model notes that arguments typically will consist of six parts. He used these terms to describe the items: Data which are the facts or evidence used to prove the argument; Claim are the statement being argued; Warrants are the hypothetical statements that serve as bridges between the claim and the data; Qualifiers that limit the strength of the argument or that propose the conditions under which the argument is true; Rebuttals which are counter-arguments or circumstances when the general argument does not hold true; and Backings that serve to support the warrants. Toulmin's model emphasizes that arguments should be expressed with qualifiers and rebuttals rather than asserted as absolutes. This notifies the reader of the limitations of the reasoning. Here in the following is a shape of the example argument in which the various parts are incorporated:

> Based on ABET math competency requirement, an engineer must be proficient in math. John is an engineer. Therefore, John is certainly proficient in math, unless he has forgotten what he learned in school.

The results of the research will be reported as a set of probability statements about the relationships between categories and core categories or as an integrated set of conceptual hypotheses developed from the empirical data (Glaser 1998).

Establishing Credibility of Qualitative Data

Constant Comparison

This study used the constant comparative method in which any newly collected data will be compared with previous data collected. The constant comparative method is used to develop concepts from the data by coding and analyzing at the same time (Taylor and Bogdan, 1998). The constant comparative method "combines systematic data collection, coding, and analysis with theoretical sampling in order to generate theory that is integrated, close to the data, and expressed in a form clear enough for further testing" (Conrad, Neumann, Haworth and Scott, 1993, p. 280). Constant comparison will occur throughout each of the coding stages and involves three types of comparison: concepts to concepts, concept to categories, and categories to categories. Constant comparison is meant to assure that all data are systematically compared to all other data in the data set.

Memoing

Memo writing is expected to be fundamental to the constant comparison method and occurs in tandem with each stage of the coding process. According to Glaser (1998), the purpose of memo writing is to “capture, track and preserve conceptual ideas” (p.180). I consider this an essential part of this research because of my professional experience with the subject being studied. To mitigate or minimize the effects of researcher bias, Glaser (1998) suggest the use of memos to capture the many “non-grounded ideas occurring from personal biases, personal experiences of an idiosyncratic nature, logical conjectures or deductions [and] received preconceptions” (p. 182).

Trustworthiness

Many frameworks have been developed to evaluate the trustworthiness of qualitative data (Guba, 1981; Lincoln and Guba, 1985). I am proposing several basic key elements to the study design to enhance the overall study trustworthiness. To achieve trustworthiness, I am proposing to ensure: (a) Triangulation of the data and methodology; (b) Validity of the study; (c) that the study is dependability as related to stability of the data over time; (d) that the process and data is confirmability; (e) that the data are collected and managed systematically to indicate transferability; (f) the data are accurate and consistent; and (g) that the researcher will be reflexive.

Triangulation

Triangulation is a salient part of the theory building process to enhance validity and trustworthiness (Glesne and Peshkin, 1992; Guba, 981).

Triangulation is a technique used to accurately increase fidelity of interpretation of data by using multiple methods of data collection (Glesne and Peshkin, 1992). In addition, it is used to capture different dimensions of the same phenomenon. Triangulation usually depends on the convergence of data gathered by different methods; it can also be achieved using the same method gathered over time (Kolb, 2012). It is expected that this study will be enhanced by both methodological and data triangulations. Methodological triangulation involves the use of multiple methods to collect data. Each method has different strengths and weaknesses. However, methodological triangulation balances them out, and therefore creates a richer and more robust account (Bekhet and Zauszniewski, 2012). Data triangulation involves using different sources of information in order to increase the validity of a study (Halcomb and Andrews 2005; Casey and Murphy 2009). Data triangulation is used to verify a piece of data or a finding with several different data sources.

Validity

Validity refers to the equivalence of research results with the objective reality (Czarniawska, 1998). Validity in qualitative research means “appropriateness” of the tools, processes, and data. Whether the research question is valid for the desired outcome, the choice of methodology is appropriate for answering the research question, the design is valid for the methodology, the sampling and data analysis is appropriate, and finally the results and conclusions are valid for the sample and context (Leung, 2015).

Dependability

Dependability refers to the stability of the data over time and over the conditions of the study (Polit and Beck, 2014). Dependability ensures that the data represent the changing conditions of the phenomenon under study. The use of an inquiry auditor is a valid strategy for ensuring research dependability (Brown, Stevens, Troiano and Schneider, 2002). The inquiry auditor guarantees grounded theory procedures are followed through understanding the coding and examining the emerging theory and its categories and verifying that they are used correctly (Brown, et al, 2002). This objective auditor ensures stakeholders-participants, readers, and dissertation committees - that emerging codes, concepts, and theories are dependable (Lincoln and Guba, 2000; Strauss and Corbin, 2008).

Confirmability

Confirmability refers to the degree to which the results could be confirmed or corroborated by others. To achieve confirmability, I propose to maintain an audit trail of analysis and methodological memos of log (Brown, et al, 2002). A confirmability audit can be conducted at the same time as the dependability audit and the auditor asks if the data and interpretations made by the inquirer are supported by material in the audit trail (Guba and Lincoln, 1985).

***T*ransferability**

Transferability refers to the applicability of one set of findings to another setting. Transferability is strengthened with a rich, detailed description of the context, location, and people studied, and by being transparent about analysis and trustworthiness (Amankwaa, 2016).

Reflexivity

Reflexivity is an awareness of the ways in which the researcher's background has an impact on the research process (Robson (2002). A major threat to the trustworthiness of the research can be the researcher himself (Kolb, 2012). I bring some experience to the study, which has the potential for researcher's bias. However, from (Strauss and Corbin, 2008) perspective, the researcher's previous experiences are data. No effort is made to put aside ideas or assumptions about the situation being studied (Strauss and Corbin, 2008). The researcher uses their ideas and assumptions in order to better understand the processes being observed (Baker, Wuest and Stern, 1992). According to McGhee, Marland and Atkinson (2007), Neil (2006) argues that the potential impact of the researcher on the data needs to become part of the research record in order to be explored through constant comparative analysis.

This awareness should not be suppressed but shared with readers. Researchers should openly acknowledge the influence of prior work or experience on their perspective (Charmaz 2001). The researcher's voice should not only be explicitly recognized, but also analyzed as an influential element in the resulting theory. For Strauss and Corbin (2008) both use of self and the literature maybe used to stimulate theoretical sensitivity and generate hypotheses. Memo writing is a useful tool for capturing the researcher's ideas and assumptions. The analysis can be equated to a discussion between the data, the memos and the researcher (Backman and Kyngas 1999).

CHAPTER IV

INTERPRETATION OF RESULTS

This chapter begins by presenting the concepts and categories identified during open coding and linked together as part of the axial coding process to create the theoretical framework that describes the phenomena being studied. The chapter continues with a more detailed description of the categories that make up the core-category and how they may be influenced by humanities and social thought. These descriptions are followed with a discussion of the core-category, 'Sustainable Civil Infrastructure Projects'. The chapter concludes with a set of assertions about humanities and social thought in sustainable civil infrastructure projects, as entry-level civil engineers appear to deal more with the practical aspects of projects.

One of my goals for this chapter is to accentuate the creativity of the data over my creativity as the researcher who carried out the review. Consequently, report of the results is substantiated with explanations of the data and their relations with established civil engineering practice. The results of this grounded theory study are expressed as a substantive phenomenon and a set of assertions, that is, as a set of concepts that are related to one another in a cohesive whole.

This grounded theory study used entry-level civil engineering students' work experiences to generate an explanatory framework for examining the modes of humanities and social thought in entry level civil engineering practice. Data was collected using three data sources in chronological order, starting with job advertisements and followed by a focus group and case study. These three sets of qualitative data provided the incidents for constant comparison and the classifications for subcategories. During initial coding, integrating patterns emerged from comparing the incidents and was consolidated into 112 subcategories. These subcategories were integrated into seven conceptual categories – Context Sensitive Design, Environmental Stewardship, Sustainable Project Management, Sustainable Communication, Economics and Financial Management, Rules for Sustainability, and Ethical Conduct – which are discussed in depth in the following sections.

Context Sensitive Design

The Transportation Research Board of the National Academies define Context Sensitive Design as the project development process, including attempts to address safety and efficiency while being responsive to or consistent with, the natural and human environment. Within this definition are the terms – safety, efficiency and natural and human environment – all of which have direct influence on the human condition. To further that mindset, the Federal Highway Authority (2009) describes Context Sensitive Design as a collaborative, interdisciplinary approach to design that leads to preserving and enhancing scenic, aesthetic, historic, community, and environmental resources, while improving or maintaining safety, mobility, and infrastructure conditions. According to federal and state guidelines, the topics that commonly fall under a context sensitive solution include: access, mobility, connectivity, social isolation/splitting of neighborhoods, history of the community, new development impacts, changes in the quality of life, changes in neighborhood identification, changes in property values, separation of the neighborhood from community facilities, displacements, impacts on community centers of activity whether formal or informal, noise, urban renewal, removal of urban blight, joint land use, and disruption of the natural and human environment. The coding paradigm comprising ‘Context Sensitive Design’ of civil infrastructure projects as found by this research is presented in Table 4.1.

Table 4.1. Coding Paradigm for Context Sensitive Design

Sub-Categories	Coding Paradigm	Categories
Need for the Project	Causal Conditions	Context Sensitive Design
Guiding Principles	Context	
Design Guides		
Project Scope		
Community Characteristics		
Project complexity	Intervening	
Project needs		
Impeding Factors		
Unstructured Problems		
Project Risks		
Planning and development	Action/Interaction Strategies	
Preliminary Concepts		
Alternatives		

Table 4.1. Coding Paradigm for Context Sensitive Design (Cont.)

Sub-Categories	Coding Paradigm	Categories
Detailed Design	Action/Interaction Strategies	Context Sensitive Design
Plan Development		
Specifications		
Engineering Principles		
Creativity		
Project Teams		
Public Input		
Public Interaction		
Publicity		
Public Partnership		
Economic Justification		
Data Collection		
Data Analysis		
Data Management		
Data Aggregation		
Community Characteristics		
Collaboration		
Coordination		
Sustainable Design	Consequences	

Causal Condition

Many factors led to the occurrence of context sensitive designs of civil infrastructure. The Purpose and Need statements for projects in the Case Study explained why the organization was undertaking the proposed action and its objectives. The "Need" identified some deficiencies or problems (e.g., traffic congestion, safety, deteriorating physical condition of a facility, etc.) that needed to be addressed. A review of the data from the Case Study showed that a deficit in a civil infrastructure system caused a need for a project that aimed to correct the deficit. According to the data, entry-level engineers were assigned to some of these projects. For example:

(1) *"The Metro Transit Facilities and Police departments are in need of additional space to facilitate their daily operations".*

(2) *The internship is extended so that* [redacted] *can continue the second year of her internship with E&F. She would continue to work on the Be the Solution program, sustainable waste project, renewable energy project, APTA Sustainability and Multi-modal Conference, water conservation projects (Rain water garden grant received for Transfer Road), grant application writing (water, storm water, electric vehicles), expansion of electric staff cars and charging stations, and reporting on our Sustainability efforts.*

(3) *Engineering and Construction has a backlog of funded projects. Some of the work that would be assigned to this internship is: Various sustainability projects; various water resources projects;*

Pedestrian barriers @ Rice St. & 4th St; various bridge maintenance projects; and assist in the Park & Warehouse Crossovers Project.

(4) *Project participation will include engineering services and site inspections on Better Bus Stop projects, Park and Ride renovation projects and Transit Center renovation projects.*

Drawing from the Case Study, the "purposes" for the projects were broad statements of the primary intended project result (e.g., improve mobility, improve traffic condition, improve efficiency and safety) and other related objectives to be achieved by a proposed improvement. For instance:

(1) *This project is to perform construction services that will bring the Heywood II site in compliance with the City and Watershed stormwater better management practices.*

(2) *The landscape asset inventory is a new project that will improve the future design and maintenance of landscaping at transit facilities, resulting in lower costs, better environmental stewardship, and more attractive facilities for customers and communities.*

According to the Federal Highway Administration, the purpose and need are the foundation of the decision-making process, influencing the rest of the project development process, including the range of alternatives studied and, ultimately, the selected alternative.

Context Condition

The term context has been defined to represent various factors and conditions surrounding and influencing the use of a system. Guiding principles articulate the fundamental goals that all decisions can be measured against and thereby keep the project moving toward an integrated whole. Guiding Principles represent the accumulated wisdom of researchers and practitioners in design and related fields and inform us of how users will likely react to our creations. Effective Guiding Principles account for a product's (e.g. bridge, facility, road, etc.) specific user needs and business goals. One Council policy from the Case Study states one of the organization’s Guiding Principles:

> *“The Metropolitan Council is committed to being a responsive and participatory agency for regional decision-making. The Council believes that by keeping the regional planning and service-delivery process customer-focused, open and participatory, it can reflect the shared values of the metropolitan community and obtain the best available information for responsible regional decision-making.”*

Specifically, Job Descriptions for entry-level civil engineers made it explicit that engineering principles are salient to entry-level engineering practice by explaining, for example:

> *“This position requires an individual capable of applying engineering principles in the design development process of highways and transportation improvement projects of a broad scope and complexity.”*

The importance of guidelines was also evident in the Focus Group data when participants stated that engineering students, "*must know the theory behind guiding principles*".

Another contextual factor is the Design Guide. Design Guides are sets of recommendations towards good practice in design. My review of the entry-level civil engineers' project files in the Case Study found that their designs were guided by specific guidelines. For example:

> *Station and Support Facility Design Guidelines; Regional Transitway Guidelines; Guideline for the Location and Design of Bus stop; Manual on Pedestrian and Bicycle Connection to Transit.*

And in the Job Description data employers made the application of Design Guides a requirement. For example:

> *"This position requires an individual capable of applying design guides in the design development process of highways and transportation improvement projects of a broad scope and complexity."*

Guidelines are intended to provide clear instructions to designers on how to adopt specific principles. A design guideline is intended to help designers understand how to implement a principle, without restricting their creativity in design. Design guidelines emerge from various sources (e.g. building codes, design codes, city ordinances, etc.). Due to the varied sources from which guidelines originate, some may conflict when applied under different contexts of design (e.g., designing for the visually impaired vs. for the sighted; or designing for an urban setting vs. a rural setting). For this reason, design guidelines are not as generalizable as guiding principles.

The scope of the project presents additional context with which to contend. The Focus Group identified that an outcome of a 21st Century Civil Engineering Curriculum must include the ability to scope a project, stating: *“Ability to scope a project”*: “and *“Students will learn: how to identify potential issues”*. The Case Study data also revealed that entry-level engineers prepared scope of services and scoping documents for projects. For example, one engineer prepared the scope of service for a design contract for the “*Ramsey Commuter Rail Station”*; another entry-level engineer also prepared an environmental scoping document for the “*I-35W/95th Ave. park-and-ride*”. A job justification for hiring entry level engineers in the Case Study includes performing Scope of Work (SOW):

> “*Assist with development of RFP, SOW, etc. for design project as well as for other required services (surveying, soils investigations, environmental evaluations, prep info for FTA submittals, etc.)*”

While a project may seem to have a clearly defined scope, there is a need to understand its context to define the scope properly. A well-defined scope establishes expectations among the project stakeholders. Scope is derived from context and it identifies the external interfaces between the project and the rest of the world.

Some contexts are composed of factors that reside in users such as cultural and mobility. Some are composed of external factors that reside in operational environments such as organizational, spatial and social factors. Other contexts may be internal to the stakeholder such as perception and emotion. Yet other contexts might be composed of combinations of factors that are distributed across users, systems and operational environments. It is therefore a salient requirement of Context Sensitive Design to have early and continuous commitment to public involvement. Community members play an important role in identifying context sensitive solutions; the local and regional problems and solutions that may better meet and balance the needs of all stakeholders. The Case Study data revealed that the projects and programs in which entry-level engineers participated such *as "Better Bus Stop Community Engagement and Minneapolis-St. Paul Urban Partnership Agreement program"* required engineers to understand the characteristics of the communities affected by their initiatives. According to the plan for the Better Bus Stop Community project:

> *"Metro Transit and the Better Bus Stops program is supposed to "engage and involve underrepresented communities (low-wealth, people of color, new immigrants, people with disabilities, or other cultural constituencies) in participation, decision-making, and leadership roles around regional transit equity issues at the bus stop level."*

Additionally, an entry-level engineer explained the strategy for public engagement at a certain bus stop as follows:

> *"This was our first non-transit center outreach but showing up to, a busy bus stop proved to be good outreach as well! We set up our table by the*

bus shelter where southbound 10 riders were boarding and used the existing bus shelter as a backdrop for our dot board and blank paper asking people what better bus stops mean to them. Then, we had clipboards so we could roam to the other three corners with bus stops when we saw people waiting there. This time we added the blank sheet of white paper where people could add comments with markers and that worked really well. It was an easy way to start a conversation, that then led some to filling out the dot board or survey."

An appreciation of community characteristics such as nationality, culture, language, history and sentiments were needed in order to make the initiatives relevant to the community. For example, per the Case Study data, entry-level engineers participated in Metro Transit's Public Art Policy Development project. They performed the research on, public art policies and the incorporation of public art in civil projects and developed a database on existing public art within the Twin Cities. An excerpt from the project execution plan explains:

"This project will create a Public Art policy that defines the goals and funding for Metro Transit's public art program and a Public Art Procedures document that guides planning, implementation, and ongoing operational needs of Metro Transit's public art program.

Metro Transit is using public art to enhance transit facilities for the benefit of transit customers and the local community. Research indicates that public art can benefit a transit agency by strengthening its brand, by making public facilities more appealing and safer, contributing to the *desirability of a neighborhood, providing meaningful public engagement in capital projects, and growing ridership. Through the process of developing a public art policy, Metro Transit will consider its reasons for including public art in transit projects, and find ways to evaluate the benefits of public art."*

Intervening Condition

Reviewing the project files of entry-level civil engineers in the Case Study, I found that unstructured problems such as uncertainty, community norms and values, shaped the strategies with which the entry-level engineers' projects were executed. The following is an agreement that was foundational to the strategy used for a project affecting federal land:

> *"This Agreement is entered into pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended ("CERCLA"), 42 U.S. C § 9601, et seq . and the authority of the Attorney General of the United States to compromise and settle claims of the United States."*

This agreement was for the "*I-35W/95 park-and-ride*" project. It is a Response Action Plan agreement that outlined proposed actions upon encountering certain contaminants during construction. The Response Action Plan is an agreement that addresses the uncertainty of encountering soil contaminants on a project. Yet the following excerpt from the Case Study demonstrates how the uncertainty in the permitting process shaped the engineer's strategy for managing the process:

As different municipalities may interpret and enforce the state plumbing code differently, it is my opinion the Div 22 contractor need to determine, when they start the permit process, whether plan review is to be provided by the City or State; they then should submit plans to the City or State, with the appropriate fees, to start the permit process.

Impeding factors like project budget, opposition to the project, level of impacts and characteristics of the preferred alternative, also structured the approach to a specific project. As is evident in the following extracts from all three data sources, entry-level civil engineers are required to address the problems posed by impeding factors they encountered in their assigned projects:

The following are from the "*I-35W/95 park-and-ride*" project from the Case Study. These examples show an entry-level engineer identifying the characteristics of alternative and planning for potential encounter with contaminated soil:

(1) We have provided three alternative solutions to meet your projected future parking demand of 1,400 to 1,800 spaces, to provide covered parking, and to reduce walking distance for patrons.

(2) Metro Transit has American Engineering Testing, Inc. (AET) under contract to provide Phase II environmental work on two properties the agency wants to acquire for campus expansion: 554 and 578 8th Ave N. This contract entails typical Phase II environmental activities, such as technical field work and preliminary soils analysis.

The following is a conclusion by the participants of the Focus Group interview for preparing entry level engineers for dealing with impeding project factors -

> *(3) Students must learn: how to develop public involvement strategies; how to develop a systematic process for quantitatively and qualitatively predicting effects; and, the skills necessary to identify the actions needed for thorough analysis and mitigation.*

The following is an example of a Job Description that makes addressing impeding factors a responsibility of the entry-level engineer -

> *(4) May participate in meetings with public officials and the public at large to answer questions and to advise on alternative methods to secure corrective action.*

Additionally, the following Metro Transit procedure from the Case Study, make it an organizational policy to conduct cost and price analyses to keep track of project budgets -

> *(5) Also, in accordance with Metropolitan Council purchasing procedures, section 2.1.1.8 Cost and Price Analysis, "A cost or price analysis must be performed for every procurement action, including contract modifications".*

Per the Council's Procurement Office, cost and price analyses are conducted because they have direct bearing on a project's budget and the strategic approach to specific solutions.

Other intervening factors were found to be the project risk and project complexity. Risk and uncertainty can sometimes be confused as being the same;

however, it is possible to distinguish between the two terms. Uncertainty can be regarded as the chance occurrence of some event where probability distribution is genuinely not known. This means that uncertainty relates to the occurrence of an event about which little is known, except the fact that it may occur. Civil engineers distinguish uncertainty from risk and defines risk as being where the outcome of an event, or each set of possible outcomes, can be predicted based on statistical probability. My analysis of data from the Case Study found that entry-level engineers were given work experiences with project risks. The quality assurance and quality control measures in which they participated such as specifications, cost analyses, independent testing, agreements, etc. provided the engineers with foundational work experience for addressing technical, financial and environmental project risks. Their project files from the Case Study showed the tools they used to address project risks included*, "probability analyses, peer reviews, insurance policies, bid bonds, Certifications regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion".* The following example is of an entry-level engineer's evaluation of a potential contractor's ability to perform the work for which the projected a bid:

> *I have reviewed the bid documents [redacted] Construction provided, along with the results from reviews conducted by the Purchasing office and by the office of Diversity and Equal Opportunity. Based on my review I find [redacted] Construction to have adequate financial resources to perform the contract, is able to comply with regulatory requirements, is able to deliver*

according to the contract schedule, and has a history of satisfactory performance.

Project complexity come in different forms:

(1) Structural complexity in projects relates to the complexity of the product. The number of subsystems and their interdependence, which can be, reflected through the way changes in one subsystem influence others. (Williams, 2002)

(2) Technical complexity covers technical and design issues related to the product and untried and unfamiliar techniques.

(3) Temporal complexity relates to variability over time and thus covers the uncertainty due to future constraints, expectation of change and even uncertainty of the very existence of the system. (Remington and Pollack, 2007).

The three sources of data, Job Description, Focus Group and Case Study respectively, explains entry-level engineers work complexity as follows:

"*independent engineering judgement for decision making that is appropriate for the complexity and scope of entry-level tasks; Engineers seek solutions to problems, and the economic viability of each potential solution is normally considered along with the technical aspects and complexity; Their positions exist to provide project management responsibilities for projects or tasks ranging from Minor Projects to Moderate Projects*".

Action/Interaction Strategies

Context Sensitive Design uses coordinated, collaborative, interdisciplinary approaches that include early involvement of key stakeholders. Starting with the right project team that includes a variety of professional disciplines is a core element in the success of a project. In this research, based on the three data sources, I found that interdisciplinary teams were used extensively in entry-level civil engineering practices. As a reoccurring theme in the Job Description data, entry-level engineers must be "*ability to work as a member of an interdisciplinary team, work with diverse clients*". An interdisciplinary approach to planning and design incorporates the viewpoints of the various agencies, stakeholders and professionals who have roles or areas of concern in the project. The Focus Group participants went a step further by recommending that civil engineering curriculum should develop students' "*ability to function on multidisciplinary teams*". All project team members need to ensure that the project will progress effectively and efficiently, and solutions will be delivered according to the project's intended function and the community needs. The project teams included a full range of stakeholder representing the interests and perspectives that had to be addressed. Job Description data highlighted that entry level engineers must possess the "*ability to work collaboratively in diverse teams including technical and non-technical personnel*". Practical experiences discovered in the Case Study showed that entry-level engineers assumed varying roles on project teams, for instances:

(1) *To assist the Public Facilities Team by working on small projects and assisting Project Managers on larger projects during the design and construction projects.*

(2) Management of projects and programs that support the team objectives. The duties begin with defining the effort to be undertaken, determining the payback and often continue with data analysis to track and report progress.

(3) As a Facilities Information Systems (FIS) team member, this position would draft, maintain, organize, and reproduce, floorplans.

Beyond the team comprising of staff and specialists, consideration had to be given to an expanded project team made up of representatives of the agencies, jurisdictions and the community. For example, Job Descriptions specified that entry level engineers:

> *"Develop positive relationships with co-workers, clients, citizens, regulatory agencies and contractors through tactful and effective communication."*

The Focus Group observed that the changing methods for delivering of civil infrastructure projects is also changing the composition of the design teams. They noted: "*Design build is causing civil engineers to work with engineers from different countrie*s."

The extended team typically also included people directly involved in planning for, implementing, and/or eventually living with the results of the completed project. An effective Context Sensitive Design approach allows for purposeful public participation. Purposeful meaning that the public have an opportunity to participate in decisions or contribute in a way that can influence decisions. Public participation in this research range from simply sharing information upon which decisions are based to offering the public full decision-making authority. Though the public's attitude towards a project can fall anywhere on a spectrum from active opposition, to neutral disinterest to support, through the public participation process, participants were afforded the opportunity to shape a desired end. The focus group recommended that:

(1) Students should be prepared to present their work in a public forum.

(2) That a curriculum outcome is to "*Learn to justify projects for public buy-in*".

(3) Learn to conduct open house events.

Examples of the typical Job Description requirement for the entry level engineers' involvement in public participation strategies in their projects are as follows:

(1) Meet with citizens, public officials, other government agencies, to exchange information, represent the county's interests, and ensure compliance with county policies.

(2) Interact with internal and external clients/committees, including public and private agencies, citizens, or other affected interest groups.

The Case Study of this research found that entry-level engineers used various strategies for public participation: publicity to generate public interest in the project -

(1) Media events.

(2) Project tours and Demos;

Public interactions to provide information about the project and to simply listen and learn -

(3) Open houses

(4) Public Meetings;

And public partnerships to resolve conflicts and to provide the public with various levels of approval authority -

(5) Community group sign-off

(6) Stakeholder workshop.

(7) Project focus Groups.

A general understanding of the community's characteristics provided basic information about the community such as its geographic boundaries, demographics, economic conditions. Insight into a community's local identity, its values in traditions and history, religious and spiritual practices, the way information travels, and how decisions are made gave the entry level engineers perspectives that are unique to the community as to its attitudes, values, perceptions, and interests. The Focus Group recommended that civil engineering students should be made familiar with "*Design standards and development practices that are flexible and sensitive to community values*."

Projects such as the "*Public Art Developmen*t" and the "*Better Bus Stop*", discussed previously, make it evident that entry-level civil engineering practice includes the use of community-based information. Data comprising community characteristics, such as nationalities, cultures, languages were gathered, managed and analyzed in order to make Context Sensitive Design decisions.

The Purpose and Need for a project, as well as community interest, provided the basis for developing criteria for comparative evaluation of alternatives. Project alternatives are developed based upon the most accurate understanding of a community as possible, which is why defining the community is an important first step to understanding and achieving community values through community input. Data gathered in this research affirmed that entry-level engineers are required to evaluate project alternatives in their decision-making process. The Focus Group stated, "S*tudents must learn how to develop a reasonable range of alternatives".*

The Job Descriptions required that entry level engineers:

(1) Develop preliminary engineering concepts and alternatives for review and evaluation by the Project Engineer.

(2) Use logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems.

The evaluation of alternatives and the selection of a preferred alternative appeared to be a presumed task for entry-level engineers. The selection of a preferred alternative is typically based on a feasibility analysis. Feasibility studies of civil infrastructure projects are analyses of alternatives based on cost effectiveness, impacts to the natural environment, preservation and impacts to the individual communities and safety.

Entry-level engineers are also required to participate in design tasks. A job Description specified the following for the selected entry-level engineer:

> *As part of an Engineering Team, you will be responsible for the design of civil and municipal engineering projects for highway and local roads, public utilities and public works, and related infrastructure projects.*

The Focus Group also concluded that a graduating civil engineering student must have the "*ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability".*

In most projects in the Case Study, the design phase consisted of three stages, which occurred in the following sequence: the first stage, conceptual designs were developed based on the emerging service plan; the second stage is the design development; and followed by construction documents phase. The preliminary concept design gives graphic shape to the project. It is an overall concept that illustrates key ideas of the design solution. According to some Job Descriptions, a required task for entry-level engineers are to develop conceptual designs, for example:

> *Develops preliminary engineering concepts and alternatives for review and evaluation by the Project Engineer.*

Incidents of preliminary concept designs were also evident in the Case Study and included: *site plan rendering, Concept plans, concept drawing, layout plans schematic design and design sketches.*

Once the preferred design concept is approved, the process of designing the infrastructure in detail begins. During that stage, the design concept is developed further, hence, the term design development. While the emphasis in the conceptual design stage is on the creative, conceptual, and innovative aspects of design, the design development stage focuses on developing practical, pragmatic, and constructible solutions for the infrastructure. This is an essential skill for entry-level engineers. According to the Focus Group, civil engineering students, upon graduation should be able to "*assist in preparing plans, specifications and reports*". The purpose of the construction documents stage is to prepare all documents required by the contractor to construct the infrastructure. During this stage, the engineer collaborates intensively to develop the required documentation, referred to as construction documents. In this stage, according to the Job Description data source, the entry-level engineer is expected to "*coordinate design activities to ensure installation and operations will comply with specifications, codes, and client requirements*". The construction documents consist of construction drawings and Specifications. Construction drawings are the drawings that the construction team uses to build the infrastructure. Therefore, they must indicate the geometry, layout, dimensions, types of materials, details of assembling the components, colors and textures, and so on. Engineers in the Case Study performed a variety of construction drawings such as, *shop drawings, construction details, design blowouts, as-built drawings and construction plans*.

Specifications are written technical descriptions of the design intent, for instance, the quality of materials, their properties (the strength of concrete, for example), and the test methods required to confirm with compliances that cannot be furnished on the drawings. For instance, the Case Study points to the "*underground piping system project at the Ramsey Station*" as an example where the entry-level engineer developed specifications for construction. The two components of the construction documents—the specifications and the construction drawings—complement each other and generally deal with different aspects of the project.

Consequence Condition

A consequence of Context Sensitive Design is sustainable designs. From a Context Sensitive Design perspective, sustainable design indicators reflect environmental and economic considerations, as well as local social issues relevant to sustainability. According to the Focus Group, "*Context Sensitive Solutions allows design decisions to better balance economic, social and environmental objectives*." The Context Sensitive Design of a responsibly developed site is a collaborative, interdisciplinary approach that involves all stakeholders to provide an infrastructure that fits its physical setting and preserves scenic, aesthetic, historic and environmental resources, while maintaining safety and mobility. The Focus Group describes good land development this way:

> "*Sustainable land management (SLM) is a knowledge-based procedure that aims at integrating the management of land, water, biodiversity, and*

other environmental resources to meet human needs while sustaining ecosystem services and livelihoods."

Environmental Stewardship

Environmental Stewardship has become a way to articulate broad social values that influence our relationship with the natural world. It is the responsible management of human activity affecting the natural environment to ensure the conservation and preservation of natural resources. Its enactment has come to mean the equal consideration of economic, social and ecological spheres of humanity and their inter-relationship as a whole.

Maintaining a healthy environment requires information derived from evaluating its condition within a physical, social and cultural context, herein defined as environmental assessment. Stewardship requires the minimization and mitigation of any form of negative environmental impacts. Thus, stewardship extends to the entire lifecycle of any human artefact, from production and distribution to its eventual consumption and disposal. Thus, the construction of civil infrastructure projects encompasses the full lifecycle of a human artefact. Therefore, the entry-level civil engineers' projects' influence on the environment required assessment and their impacts required minimizing and mitigating. The coding paradigm comprising 'Environmental Stewardship' of civil infrastructure projects as found by this research is presented in Table 4.2.

Table 4.2. Coding Paradigm for Environmental Stewardship		
Sub-Categories	**Coding Paradigm**	**Categories**
Utility Impacts	Causal Conditions	Environmental Stewardship
Transportation Impacts		
Environmental impacts		
Land Development Impacts		
Project Scope	Context	
Legitimation of Environmental Issues		
Impeding Factors	Intervening	
Unstructured Problems		
Environmental Investigation	Action/Interaction Strategies	
Environmental Engineering		
Environmental Documentation		
Alternatives		
Environmental Justice		
Environmental Mitigation		
Environmental Compliance	Consequences	
Environmental Sustainability		

Causal Condition

Humans affect the environment in several ways. Common effects include decreased water quality, increased pollution and greenhouse gas emissions, depletion of natural resources and contribution to global climate change.

Environmental impact concerns have been a longstanding issue that necessitates environmental stewardship. Environmental concerns and stewardship can be dated back to the third millennium B.C. The episode called Forest Journey from the Epic of Gilgamesh tells of the likely consequences of uncontrolled deforestation. In the Unites States, from the earliest days, the Colony settlers recognized the great value of the tall white pine trees as lumber, for exporting in exchange for needed commodities, and for tall masts for big ships. The first legislation in America having as an object the conservation of the supply of timber appears to have been the order of the Plymouth Court, dated March 29, 1623 (Kinney, 1972).

Today, environmental impacts remain a source of public concern. Experiences have maintained that human activities can be at odds with the natural and human environmental and their impacts remain a causal condition for environmental stewardship. The entry-level engineers in the Case Study encountered several conditions, which triggered cause for environmental stewardship. Examples of projects that had conditions that were cause for environmental stewardship included *I-35W/95 park-and-ride, Heywood Garage, O&M Facility Expansion, etc*. These conditions included utility impacts (e.g. encroachment on private property rights) transportation impacts (e.g. pedestrian accessibility, aesthetic, safety, noise and vibrations), environmental impacts (e.g. water quality, air pollution, and soil contamination) and land development impacts (e.g. construction noise, soil erosion, traffic congestion, and ecology sensitivity).

One defining factor of civil infrastructure projects is the failure to view Indigenous stakeholders as sovereign nations or understand their unique land rights and responsibilities (von der Porten and de Loë, 2013). Indigenous people assign a host of distinct values: spiritual, aesthetic, religious, scientific, cultural and/or historic. According to Jennifer Welchman (2012):

> "To cherish an entity for its beauty, its spiritual meaning, or its cultural significance is to view it as something other than a disposable resource. And the values conferred by beauty, spiritual meaning, and cultural significance are neither reducible to one another nor to any further type of value, say economic or welfare value." (p. 18)

To that end, the Job Descriptions data source includes incidents that required entry-level engineers to, for example, "*work with community liaison to inform public about upcoming work and potential impacts*". *The "Better Bus Stop Community Engagement program*" in the Case Study provided entry-level engineers with the needed project experience working with indigenous people on civil infrastructure projects. Better Bus Stops is a project to enhance access to opportunities by investing in bus stops. The project focused on Neighborhoods that contain areas of concentrated poverty where more than half of the residents are people of color. It is committed to use community feedback to inform future bus stop investment decisions. Community feedback addressed all aspects of the transit experience including the broad themes of bus service and operations, equitable distribution of resources, fares, and safety. In accordance with the project theme, entry-level engineers coordinated design efforts with the

Phillips Seward Little Earth of United Tribes for bus stops in the Phillips Seward community, in Minneapolis.

Social and cultural changes are a reality for communities hosting civil infrastructure projects. These changes can include value systems, traditional lifestyles, family relationships, individual behavior or community structure. Therefore, the effects of civil infrastructure projects can also include the social environment. Based on data from the Case Study, entry-level engineers at Metro Transit were also engaged in the social effects of environmental impacts. For example, the data included incidents of entry-level engineers engaging in the preparation of environmental impact studies. These studies aimed to address the impacts of civil infrastructure projects on the social environment as is evident in the following statements from the Case Study and Focus Group data sources:

Case Study

(1) The Envision 2040 General Plan embraces "planning for people, not just cars" and "creating walkable and bike friendly neighborhood villages" to transform San José from a suburban city dominated by the automobile into an interconnected and vibrant city.

(2) We previously commented on this project on 10 December 2007 and concluded that no historic properties listed on or eligible for the National Register of Historic Places would be affected by the proposed project.

Focus Group

(3) Introduce students to the manner in which land development engineers must consider planning, environmental, social and sustainability issues.

Context Condition

The scope of a project outlines the objectives of the project and the goals that need to accomplish to achieve a satisfactory result. It Identifies the context in which the project is to be delivered, and the key constraints and assumptions. Scope refers to the detailed set of deliverables or features of a project. These deliverables are derived from a project's requirements, the work that needs to be accomplished to deliver a product, service, or result with the specified features and functions. Proper scoping is intended to achieve an effective and efficient environmental assessment. It is also intended to identify the appropriate environmental assessment process and define what needs consideration. The entry-level engineers in the Case Study were involved in drafting numerous effective and efficient scoping documents for their projects. The following are examples of incidents demonstrating entry-level engineer's work:

(1) Assist with development of RFP, Scope of Work (SOW), etc. for the cedar Grove project as well as for other required services (surveying, soils investigations, environmental evaluations, prep info for FTA submittals, etc.)

(2) Assist with development of RFP, Scope of work, etc. for design project as well as for other required services (surveying, soils investigations, environmental evaluations, prep info for FTA submittals, etc.) for all stations (Lake Street, 66th Street, American Boulevard, 98th Street, and Burnsville).

(3) Scope of work for a snowmelt system for the pedestrian bridge crossing the LRT tracks at the 4th Street and Chicago Avenue intersection serving the Minnesota Multipurpose Stadium.

Effective scoping is that which focuses the environmental assessment on environmental issues and concerns that are relevant to a proposed project. Efficient scoping defines the scope of the environmental assessment early in the process.

In addition to project scope, Metro Transit's legitimation of environmental issues suggests the company approaches environmental issues as opportunities for improvement. The company's, "*Outreach Policy, Environmental Sustainability Policy, Public Hearing Procedure, Public Participation Procedure, Public Involvement in the Transportation Planning Process Procedure and Accessibility Policy"*, are all incidents within the data, which suggest the company's commitment to environmental stewardship. Sharma (2000) in the article, *Managerial Interpretations and Organizational Context as Predictors of Corporate Choice of Environmental Strategy*, confirmed the hypothesis that, "The greater the degree to which a company's managers interpret environmental issues as opportunities, the greater the likelihood of the company exhibiting a voluntary environmental strategy. Conversely, the greater the degree to which its managers interpret environmental issues as threats, the greater the likelihood of a company exhibiting a conformance environmental strategy” (p. 684). The article further confirmed that “higher legitimation of environmental preservation as an integral part of corporate identity, higher discretionary slack available to managers for reducing environmental impact, and higher integration of environmental indicators in employee evaluation systems-will lead to lower threat interpretations of environmental issues’ (p. 691).

Intervening Condition

The degree to which an organization lacks factual or competent information concerning a project’s environmental condition reflects the project risk. There are many environmental factors that can affect a project, and the effect of some of them may not be obvious. To manage the development of a project successfully, engineers must consider the impacts of uncertainties surrounding environmental issues. Under uncertainty, decisions often have to be made without sufficient information about environmental factors, and it is difficult for project managers making decisions to predict changes in the project’s scope. Uncertainty of the environment increases the risk of project failure and makes it difficult to calculate the costs and probabilities of risks. This presents a level of business and project risk for project proponents that can be an impediment to investment and thus, an impediment to the project budget and resources. Likewise, an impediment on a project’s budget and resources has adverse effect on addressing environmental risk. Records of the entry-level engineers’ projects from the Case Study showed emphasis on unknown site conditions and contamination as examples of an unstructured problem, the uncertain extent of which posed project risks. This Example is from the Heywood Garage project. This is an example of investigative work to determine the extent of potential contamination on the site by looking at its history of use:

> "*Portions of Ragstock were developed beginning in the mid to late 1880's. Since that time, the Property has been the site of a variety of commercial operations, including: two gasoline stations; truck terminals; lumber yard; junk yard; auto salvage yards; and other manufacturing and warehouse operations that involved painting (spray booths) and chemical storage. In addition, the property has been previously filled-in, including a portion of Bassett Creek that runs underneath the property.*"

Action and Interaction Strategies

As civil infrastructures are constructed, their development and existence can sometimes result in adverse effects on the human and natural environments. Their effects on the environment are therefore matters of concern for environmentalists, civil engineers, and, indeed all stakeholders. Therefore, civil infrastructure activities must be monitored. An environmental assessment is a study that is required to establish all the impacts either positive or negative about one particular project. It consists of technical evaluation, economic impact and social results that the project will bring. The environmental assessment has to do the following: predict whether there will be significant adverse environmental effects; identify possible environmental effects; and propose measurements to mitigate adverse effects. An assessment is not a means to approve or disapprove a project but is simply a source of information to guide approval decisions. To get approval for their projects, entry-level engineers first had to conduct environmental assessments. The three data sources emphases that point by including the following incidents:

Hiring managers from the Job Descriptions expects entry level engineers to be part of a team that addresses environmental mitigation issue, stating -

(1) You would be a member of a team providing environmental consulting services ranging from site investigations to remediation projects.

The Focus Group recommended that the civil engineering curriculum should provide student with the -

(2) Skills necessary to identify the actions needed for a thorough environmental analysis and mitigation.

An entry-level engineer's assignment on the Orange Bus Rapid Transit Line project stated the following -

(3) Assist with development of RFP, SOW, etc. for design project as well as for other required services (surveying, soils investigations, environmental evaluations, prep info for FTA submittals, etc.) for all stations (Lake Street, 66th Street, American Boulevard, 98th Street, and Burnsville).

Environmental assessments follow rules that are enacted by federal, state and local government agencies. The process starts with determining the "Responsible Governmental Agency" to conduct the review. The environmental review under the National Environmental Policy Act can involve one of three different levels of analysis: 1) Categorical Exclusion determination, 2) Environmental Assessment/Finding of No Significant Impact, 3) Environmental Impact Statement. The following incident from the Case Study gives an indication of the level of environmental review work entry-level engineers performed:

Project- UPA North Park and Ride at I 35W N and 95th Ave. - The action described above meets the criteria for a NEPA categorical exclusion (CE) in accordance with 23 CFR Part 771.117(d)(4).

In this project, the entry level engineer was responsible for investigating the site for seventeen potential project impacts: (1) Air quality; (2) Zoning; (3) Traffic; (4) Historic resources; (5) Noise receptors; (6) Vibration receptors; (7) Real property; (8) Hazardous materials; (9) Community disruption and environmental justice; (10) Public parkland and Recreation areas; (11) Wetlands; (12) Floodplains; (13) Water quality, navigable waterways, & coastal zones; (14) Ecologically-sensitive areas and endangered species; (15) Carbon hotspots; (16) Safety and Security; and (17) Construction.

A federal action may be categorically excluded from a detailed environmental analysis if the federal action, individually or cumulatively, does not have a significant effect on the environment. A federal agency can determine that a Categorical Exclusion does not apply to a proposed action. The federal agency may then prepare an Environmental Assessment. The Environmental Assessment determines whether a federal action has the potential to cause significant environmental effects. If the agency determines that the action will not have significant environmental impacts, the agency will issue a “Finding of No

Significant Impact". However, if the Environmental Assessment determines that the environmental impacts of a proposed Federal action will be significant, an Environmental Impact Statement is prepared. The Case Study data reveal that a "*Finding of Fact Statement"* and *a "Finding of No Significant Impact Statement"* were addressed to entry-level engineers for the Light Rail Operations and Maintenance (O&M) Facility project, which indicate they were involved in Environmental Assessments or Environmental Impact Statements. As part of the light rail system, Metro Transit expanded its existing Light Rail Operations and Maintenance (O&M) Facility located at 1810 East Franklin Avenue, Minneapolis, Hennepin County, Minnesota. The Facility is located in an area described by Minnesota statute that is environmentally sensitive, and the majority of the population are low-income persons of color and American Indian. Consequently, and environmental assessment was conducted.

Schultz (2002) extended (Batson, 1995) empathy-altruism theory to the study of environmental issues and concluded that inducing empathy for the natural environment should lead to the activation of biospheric environmental concerns. Therefore, environmental impacts are first avoided. However, when it is not practical or possible to avoid negative impacts, these impacts are mitigated. Mitigation hierarchy seeks to minimize, repair, rehabilitate, or restore the affected environment. This decision-making process frequently involves identifying, comparing and ranking alternatives based on multiple criteria set by governing agencies and multiple objectives that are established by stakeholders. Governmental regulations are normally interpreted to prohibit disparate impact if there is a less biased alternative for achieving a legitimate purpose. Thus, the guidance calls for demographic analysis at the beginning of a project review.

Most, if not all government agencies including Metro Transit, as part of their Environmental Justice strategy, collect demographic data to identify minority populations, low-income populations and those with limited English proficiency to ensure they are not affected disproportionately and adversely. As was apparent in the entry-level engineers' project files in the Case Study, a great part of their work was to collect, management, analysis and aggregate such data. The following incident demonstrates Metro Transit data collection:

> *The P&R survey has been managed annually by an intern for over 10 years; it is a regional report and data source used by many internal and external stakeholders for tracking P&R performance and decision-making related to new, closed, or improved P&R facilities.*

Data collection such as the P&R survey tracks how low-income and minority populations are faring with decisions made on capital expenditures. It was also apparent from the Case Study data that entry-level engineers participated in evaluating projects for environmental justice issues. The follow is an entry-level engineer's conclusion for Categorical Exclusion as part of the "*American Boulevard Station and Platform Extensions*" project:

> *The project has been reviewed for its potential effect on the community. There are no readily identifiable minorities or low-income populations disproportionately impacted by this project. Therefore, the proposed*

project will not have disproportionately high and adverse human health or environmental effects to any minority or low-income populations.

Cultural recognition is certainly central to the attainment of social and environmental justice by all including indigenous people. Often, there is no substantial knowledge of the cultural needs and wishes of affected communities. Tools such as archaeological information and historic places databases are means by which way we who are removed, who are not in a position to appreciate how our past can enrich us, can be re-introduced to where we came from, and to appreciate the individual and collective human endeavor and accomplishment of those who went before. I concluded, based on analysis of the Case Study data, that entry-level engineers at Metro Transit conducted cultural investigations for their projects. The following is an excerpt from the "*Government Center Station Inter-Track Fence*" project that demonstrates engineer's involvement in that work:

The State Historic Preservation Office (SHPO) has been contacted and has determined that the project will have no effect on any cultural, historic, or archaeological resources. Please see the attached SHPO letter.

When impacts are identified in the assessment process, corrective measures are planned for their mitigation. These measures are summarized in a "*Response Action Plan (RAP)*" which were prepared by some entry-level engineers. The following statement from the Heywood Garage project in the Case Study is evidence of this:

“The Interim RAP was prepared to address the presence of known environmentally impacted soil underlying the building to be demolished. The Interim RAP also addresses known polychlorinated biphenyl (PCB) impacted concrete. The CCP was prepared to provide procedures for identification, material handling, notification and storage of contaminated material not specifically addressed by the RAP.”

A Response Action Plan is a detailed report that includes the steps to remediate negative environmental impacts. This plan is typically included in the construction documents as part of the construction contract solicitation. Unexpected environmental conditions remain a factor in every infrastructure project. Therefore, contingency plans were established and enacted to mitigate project risks. These contingency plans were set in place so that when unexpected environmental conditions are discovered during development activities, there is a clear understanding of what needs to be done. While the data had no evidence of entry-level engineers’ independent completion of a Response Action Plans and Construction Contingency Plans (CCP), the Case Study did surface evidence of their involvement in supportive work for these plans such as the following abatement summary:

Representatives of Braun lntertec inspected the Site during the abatement to observe the contractor's work practices. The results of the inspections indicated that activities at the Site were being conducted in compliance with federal and state regulations. In addition, representatives verified that *the hazardous and other regulated waste had been removed from the Site.*

Consequences

Civil engineering projects are structured by environmental and spatial objectives in many ways. Environmental rules and policies set conditions for the choice of development location and for the arrangement of functions within a development plan or other local development initiatives. The need to mitigate and compensate for the environmental effects of development or – vice versa – the need to mitigate the effects of environmental hazards on the built environment involve stewardship action. Stewardship actions are the suite of approaches, activities, behaviors, and technologies that are applied to protect, restore or sustainably use the environment and to comply with environmental laws. Environmental Compliance means conforming to environmental laws, regulations, standards and other requirements such as site permits to operate. Environment law reflects a belief that we all live together on earth and therefore no one should damage or pollute the earth any more than anyone else, and that everyone should keep damages to an absolute minimum.

The sentiments of environmental compliance and sustainability were reflected in entry-level engineers' work at Metro Transit. These sentiments were also expressed in the Case Study and Focus Group. The evidences of these sentiments can be captured in the following incidence:

In the Case Study, permission was granted to start soil grading work for the project -

(1) This permit authorizes the applicant to grading in the south east quadrant of TH 13 and TH 77 in compliance with the city of Eagan as shown on applicant's plan sheet(s).

Also, in the Case Study, the following is a Metro Transit manager's justification for hiring an engineering intern -

(2) Metro Transit has an established energy conservation and sustainability program. This internship will help support the agencies commitments to implement energy saving/producing projects and keep current with sustainability reporting requirements, utility usage, and goal progress.

The Focus Group participants agreed that graduating civil engineering students would be expected to -

(3) Perform construction quality assurance, contract administration, permit inspection and compliance, utility relocation coordination and inspection.

The Focus Group also suggested that in waste management -

(4) As an intern in the Resource Disposal and Recovery Services (DRS) group, you can expect to carry out a variety of different tasks related to solid waste disposal facility engineering, permitting, construction, and/or environmental compliance.

Sustainable Project Management

Civil engineering sustainable project management is the application of processes, methods, knowledge, skills and experience to initiate, plan, execute, control, and close the work of a team to achieve project goals at their specified times. Civil engineering project managers are responsible for the overall success of their project within the constraints of cost, schedule, quality and safety requirements. The coding paradigm comprising ‘Sustainable Project Management’ of civil infrastructure projects as found by this research is presented in Table 4.3.

Table 4.3. Coding Paradigm for Sustainable Project Management

Sub-categories	**Coding Paradigm**	**Categories**
Goal-Strategy	Causal Condition	Sustainable Project Management
Project Complexity		
Project Scope	Context	
Business Sense		
Interpersonal Skills		
Leadership		
Competencies		
Initiative		
Project Complexity	Intervening	
Impeding Factors		
Unstructured Problems		
Project Risks		
Analytical Thinking	Action/Interaction Strategies	
Organizing		

Table 4.3. Coding Paradigm for Sustainable Project Management (Cont.)		
Sub-categories	**Coding Paradigm**	**Categories**
Planning and Development	Action/Interaction Strategies	Sustainable Project Management
Time Management		
Team Management		
Contract Management		
Client Management		
Risk Management		
Decision Making/Judgement		
Multi-tasking		
Communication		
Contract solicitation		
Contract Proposals		
Problem Solving		
Effective Management		
Cost Estimating		
Value Engineering		
Accounting		
Project Delivery		
Project Success	Consequences	

Causal Condition

I found that because some entry-level civil engineers' projects are complex and involve numerous stakeholders, having a project manager to lead the initiative and keep everyone on the same page is critical to project success. This is manifested in the following statements from the Job Description data:

(1) This position requires an individual capable of applying engineering principles in the design development process of highways and transportation improvement projects of a broad scope and complexity.

(2) Coordinate with multiple engineering disciplines to assist in development of conceptual to final civil design for industrial, military, municipal, international, and private clients.

It appeared a key driving reason for project management was aligning the project with the organization's business strategy. An analysis of the data revealed that project managers align their project management with the organization's strategy by constantly communicating: the purpose of the project – the reason for the project; a vision- what will success look like; the project strategy – how is the vision achieved; and the objectives – the specific assignments that needs to be achieved to fulfil the project strategy. The three data sources all outline the importance of communication to sustainable project management.

A job Description explains the role of communication in the engineer's work:

"This position will fulfil key communications roles by effectively coordinating with City staff, partner and neighbor agencies, and community Members."

The Focus Group stressed that the engineering curriculum must help engineers develop an "*ability to communication effectively*", to use "*graphical tool to present information*", and to be proficient in "*written, oral and technical*" communication. Likewise, in the Case Study, the Metropolitan Council expressed its belief in open communication, stating:

"The Council believes that by keeping the regional planning and service-delivery process customer-focused, open and participatory, it can reflect the shared values of the metropolitan community and obtain the best available information for responsible regional decision-making."

Entry-level engineers, as all employees, abided by that belief and incorporated it into their projects. Though entry-level engineers did not manage complex projects, they were on the project teams and their actions were conforming to the management strategy. For instance, from the Case Study:

"This position will assist project managers on multiple projects that vary in size and complexity and may manage small projects concurrently."

Context Condition

Based on my findings through analysis of all the data sources, project scope and changes to the scope were influencing factors on how projects were managed. For example, an entry level engineering position from the Job Description data source required that entry engineers "*meet with government* *officials, consultants, contractors and the general public regarding necessary design changes*". A Project Scope Statement is used to develop and confirm a common understanding of the project scope among key project stakeholders. The entry level engineers' scope statements according to the Case Study data, typically included the "*project justification and feasibility, a brief description of the project outputs and its intended benefits, a brief summary of the project major constraints, assumptions and dependencies with other projects or external initiatives and a statement of what constitutes project success*". Project scope documents are used as communications tools with all project stakeholders to ensure all have a common perception of what the projects is and what it is not, it is also used to communicate any approved changes made to the project.

A list of competencies that are relevant to entry-level civil engineers and are influential to the contextual condition of project management were outlined in the three data sources. Cumulatively they included "*leadership, business sense, initiative and interpersonal skills*". Much of what we know about what makes up the leadership of effective project managers includes the skills and competencies that contribute to it. Based on this research, it is clear that different project characteristics require a different mix of key project manager skills and competencies. The effectiveness of the project manager is critical to project success. As the project experiences greater change, uncertainty and volatility, more leadership is needed (Kotter, 2001).

Intervening Condition

The environment within which a project exist influences its characteristics. Impeding factors such as budget deficits, unstructured problems such as uncertainty, project risks such as contamination, and the general complexity of the project, all of which have been discussed in previous sections, provided bases for determining the appropriate managerial actions required to complete a project successfully. These ambiguities and complexities are the factors that explain the coexistence of different approaches to project management.

Job Descriptions data were explicit about the malleable nature of project management. One job description stated that entry-level engineers had to "*Exercises independent engineering judgement for decision making that is appropriate for the complexity"* of the project. Another job description specified that the entry-level engineer would "*Performing tasks according to assigned schedule and budget*". Projects in the Case Study anticipated project risks and included tasks meant for managing project quality assurance and quality control. A civil engineering internship for construction support for the "*Mall of America Platform*" project stated, "*Performs construction quality assurance, contract administration, permit inspection and compliance, utility relocation coordination and inspection*".

Unstructured problems as uncertainty was at the forefront of many of the job descriptions. One job description found it necessary to address the uncertainty of public support for a given project by making it a requirement that the candidates had to have "*strong outreach and communication skills and can* *and effectively interact with various stakeholders in situations that are sometimes controversial and/or ambiguous*".

Action/Interaction Strategies

In civil engineering project management, there are five phases: initiating, planning, executing, controlling and closing. Entry-level engineers were given autonomy to conduct all five phase of project management for smaller fewer complex projects but were more closely supervised on more complexed projects.

Initiating. This is where all projects begin. The value of the project is determined, as well as its feasibility. I found that entry-level engineers participated in this phase of project management by developing feasibility studies and conducting feasibility analyses of alternatives. This is an indication of that work, taken from the "*I-35W/95 park-and-ride"* project:

> *"[redacted] and [redacted] [redacted] Consultants are pleased to provide you this Feasibility Study. Our several visits to the site confirmed your concerns that the existing capacity will soon exceed the 900 spaces with the additional 110 spaces to be added in 2007."*

Planning. In this phase, the project manager defines the project scope and accordingly develops a project plan that balances project priorities within the project constraints. The following two examples statements from the Focus Group and Job Description data demonstrate that entry-level engineers are expected to be proficient planners:

(1) Prepare student for Transportation planning (e.g., travel forecast modeling).

(2) This position is in the Transportation Planning group and focuses on developing long-range multimodal area transportation plans, including plans for east, west, and downtown San José.

Executing. This phase of the project management process appeared to be where the entry-level engineer was the most susceptible. The required skills most referenced in the three data sources were as follows:

(1) Analytical Thinking. For example, a Job Description described Analytical thinking *as "approaching a problem or situation by using a logical, systematic, sequential approach".* The Focus Group stated that civil engineering student must learn to "think critically about information".

(2) Organization and Planning. Many of the Job Description required engineers to be good planners and organizers. An example of this requirement statement is, "*Must have solid skills in the following areas: planning and scheduling; organization; problem solving; and decision".* The Focus Group proposed that the curriculum must focus on "*Project planning*" and "*Introduce students to the manner in which land development engineers must consider planning*". In practice, the Case Study required entry-level engineers to conduct, "*Site planning and development*" exercises such as, "*site selections, concept plans, feasibility studies, etc.*"

(3) Time Management manage. The team's time to ensure that the project maintains its schedule. From the Job Description, engineers are

expected to "*Organizes and prioritizes workflow in order to meet project timelines*" and to have "*strong time management skills to effectively manage workload*". The Focus Group would like the curriculum to *"furnish students with the skills and knowledge they need to plan, schedule, and understand control measures and systems to effectively manage a project.* At the project level, the Case Study demonstrated that entry-level engineers are to manage their "*project milestone schedule*" by using such methods as "*Critical Path Method schedules*".

(4) Team Management. Delegating, goal setting, performance evaluations and conflict management. According to a typical Job Descriptions, entry-level engineers must "*oversee and maintain project teams*". The Case Study projects showed that engineers performed "*design team coordination*" and oversaw "*team member work schedules*".

(5) Contract Management. Identifying the needs, reasons, and ultimate goals that require a contract. Serve as the main facilitators for negotiations, recommendations, record keeping, monitoring, and amending contracts. In the Job Description, engineers are tasked with the responsibility to manage contracts with such requirements as, "*ability to administer major multi-part contracts, assist in the preparation of contract and assisting senior design personnel in developing and completing contract documents*". The Focus Group believe students must learn the "*principles of construction contracts*

and basic contract law” and the curriculum must “*provide an introduction to construction contracts management*” in order to effectively manage contracts. Statements by entry level engineers such as, “*Based on my review there is adequate financial resources to perform the contract*” makes it evident that engineers in the Case Study, they were responsible for monitoring contracts. This procurement document from the Case Study, “*Authorization of CIM for sole source procurement of a mechanical construction contract for the installation of a snowmelt heating plant system at US Bank Stadium Station Pedestrian Bridge in downtown Minneapolis*”, is also evidence that entry-level engineers administered contracts.

(6) Client Management. Take responsibility for all aspects of the working relationship between clients and the organization. In the public sector such as the Case Study, civil engineers’ clients are the public and other government organizations. Requirements such as, “*provide quality service to clients, establish and maintain rapport with civil engineer clients and Ability to build and maintain strong client relationships”* in the Job Descriptions make it clear that client management is an important part of entry level engineering practice. The Focus Group also required that graduate engineers are “*able to communicate with clients*”.

(7) Risk Management. Planning for potential external events that will negative impact on the project. The Focus Group explicitly makes,

"*risk management*" a part of the engineering curriculum. The Case Study highlighted that requirement. The "*quality assurance and quality control*" measures, as well as "*contingency plans* and risk analyses" that were performed by entry-level engineers are all practical applications of risk management.

(8) Decision Making/Judgement. Make prompt, informed, and fact-based decisions. According to the Focus Group, graduate civil engineers are to "*demonstrate good engineering judgement*". The Job Descriptions require that entry-level engineering candidates, "*exercises independent engineering judgement for decision making that is appropriate for the complexity and scope of entry-level tasks*".

That they make "*independent judgment on day-to-day work and decisions*". And are "*capable of making rapid decisions with input from senior staff*"

(9) Multi-tasking. Is the ability for switching between multiple tasks and shifting attention between tasks that may occur over a short time span (Oswald, Hambrick and Jones, 2007). Typical descriptions from both the Job Description and Case Study data for advertised entry level job state that engineers should have the, "*ability to work independently on multiple projects and capable of working" on multiple projects simultaneously"*.

(10) Communication. The primary functions of communication in project management are 1) to build an effective team, 2) to share information,

and 3) for transparency. These causal conditions of communication will be discussed in a later section of this dissertation.

(11) Contract solicitation and proposals. The procurement of goods and services for the project and responding to request for proposals. "*Assist in preparations of bid packages and procurement*"; "*Manage procurement documentation for all contractors to be hired"; and "Development and delivery of proposals for quoted work projects",* are all tasks outlined in entry-level engineers Job Descriptions. These tasks are in accordance with the Focus Group's recommendations to prepare civil engineers to "*put together a proposal*". A review of the data in the Case Study show that engineers solicitated contract by various means including, "*Request for proposals, Sole source proposals, Invitation for construction bids and Micro-purchases".* It is also evident that engineers reviewed contract proposals. This is an example statement from the "*METRO Orange Line*" project, "*I have participated in the preparation and review of the Bidding Documents for this project and agree that the Bidding Documents represent items requested and/or agreed to for this project.*"

(12) Engineering Principles. Standard practice and basic principles needed to prepare quality design and construction documents for a successful infrastructure project. The following are incidents from the three data sources that makes it evident that knowledge of civil engineering principles is important for civil engineering practice:

(a) Job Description – “*This position requires an individual capable of applying engineering principles in the design development process of highways and transportation improvement projects of a broad scope and complexity.”*

(b) Focus Group – “*demonstrate strong knowledge of engineering principles*.”

(c) Case Study – Position justifications for civil engineer interns have this typical statement: “*It is expected that this person will be exposed to some basic construction and engineering principles, including the ability to work with both project designers and construction oversite staff*.”

Controlling. This phase of project management is to track three vital components of the project, which are costs, schedule and quality. These translate into controlling project scope, meeting quality requirements, keeping projects to schedule and budget, managing risks, identifying issues, and ensuring projects benefit the organization. The three data sources highlight the necessary participation of entry-level engineers in this phase of project management.

Job tasks from the Job Description data such as, “*Able to demonstrate effective project management and time management to meet project deadlines and remain within budget.”, “perform cost and schedule estimates for projects” and “understands and adheres to budget, schedule, and quality requirements”,* as well as the focus group’s recommendation to, “*furnish students with the skills and* *knowledge they need to plan, schedule, and understand control measures and systems to effectively manage a project*", make this point clear.

Closing. The last phase of the project is closing it out. This involves make sure the project deliverables have been completed as planned. The Closeout phase also includes ensuring finalizing all outstanding contracts and administrative matters, archiving the paperwork and disseminating to proper parties. Entry-level engineers in the Case Study were assigned closing tasks such as "*grant closeouts, construction closeouts, As-built drawings and project closeout coordination"*.

Consequence Condition

Project success can come in varying levels and increments, and a consequence of project management can be project failures. Based on the data from the Case Study, entry-level engineers were able to complete their assigned projects as they engaged in project closure assignments. For example, "*Project closeout coordination*"; "*Grant closeouts*"; "*Construction closeouts*"; and "*Closeout checklists*". However, varying levels of success in maintaining the projects' specified scopes, budgets, schedules or qualities were apparent as the engineers conducted various change orders. For instance:

(1) Cover the down time cost for the equipment and labor while waiting for a solution for an elevation design error while tying into an existing sanitary MH. Time extension of 14 days for the Substantial and Final Completion dates while waiting for the watershed permit approval.

(2) *We concur with Mn/DOT's recommendation for materials and methods needed to effect this change. As estimated quantities were used in preparation of this document it is understood that the final costs of this change will be determined by the actual quantities used in the project, as recorded by Construction staff.*

Communication

Communication is the process of transferring information, meaning and understanding from sender to receiver (Gibson, 1997)**.** The results of this research suggest that an important underpinning of the entry-level engineer work experience is effective communication with stakeholders. The ultimate goal is to collect and disseminate useful information that will lead to better decisions during planning and project development. Excellent communication is a critical component of project success. In fact, according to the Project Management Institute (PMI), most project failures are due to communication issues. Project communication management ensures that does not happen. The coding paradigm comprising 'Sustainable communication' of civil infrastructure projects as found by this research is presented in Table 4.4.

Table 4.4. Coding Paradigm for Sustainability Communication

Sub-Categories	Coding Paradigm	Categories
Building Effective Teams	Causal Conditions	Sustainability Communication
Share Information		
Ensure Transparency		
Interpersonal Communication	Context	
Intrapersonal Communication		
Organizational Communication		

Table 4.4. Coding Paradigm for Sustainability Communication (Cont.)		
Sub-Categories	**Coding Paradigm**	**Categories**
Group Communication		Sustainability Communication
Public Communication		
Language Barrier	Intervening	
Emotional Barrier		
Knowledge Barrier		
Technical Communication	Action/Interaction Strategies	
Technical Writing		
Verbal Communication		
Written Communication		
Correspondence		
Effective Communication		
Graphical Communication		
Bi-Lingual communication		
Listening		
Presentation		
Consensus	Consequences	
Cooperation		

Causal Condition

In a civil infrastructure project team, the members share information and share responsibility for the team's work. An important team-building strategy in which entry-level engineers engaged is open and honest communication between members of their teams. Per the Job Description data, engineers are expected to, "*have interpersonal skills that allow free flowing and creative communication to understand and resolve the issues of all levels of stake holders*".

Another job description underscored collaboration through communication stating that entry-level engineers are to "*collaborate with project managers and design staff to provide status updates, discuss challenges, and address plan revisions*". The building blocks of an effective civil engineering teams is interaction and cooperation. Through collaboration, communication teams become more collectively effective than the sum of their individual member contributions.

Entry-level engineers also applied the principle of transparent communication in their work. While some matters were to be held in confidence, most of the entry-level engineers' communications were share with everyone involved. The "*Better Bus Stop*" project from the Case Study has a communication plan that states:

> *"The community engagement goals are to engage with traditionally underrepresented communities, to increase transparency about bus stop and shelter investments, and to engage community to learn about bus stop improvement priorities."*

Public involvement, which is a core requirement of both Context Sensitive Design and environmental stewardship, involves facilitating effective stakeholder communication. One job description asked that entry-level engineers perform, "*daily contact with the public to provide information about proposed work and project status, and to respond to complaints*". And the Focus Group made transparency a focal point of civil engineering preparation by requiring, "*Students should be prepared to present their work in a public forum.*"

Context Condition

The context of a communication interaction involves the setting, scene, and expectations of the individuals involved (McLean, 2005). Entry-level engineers communicated in many contexts across their projects including the following:

(1) Intrapersonal communication. This communication context was most evident with engineers at Metro Transit who worked on construction management tasks. In the Case Study data are examples of such forms of communications including, "*Job diaries, field notes, daily Journals and serial memos"*. Intrapersonal communication or "self-talk" is how the entry-level engineers talk themselves through situations by using language to reflect on their experiences.

(2) Interpersonal communication. Interpersonal communication involved two people and ranged from formal to informal. The purpose of this form of communication was primarily to share information with individual project stakeholders. This is an example of this communication by a graduate engineer in the Case Study:

"Dear Secretary [redacted]:

We are happy to report that the many projects included in the Minneapolis-St. Paul Urban Partnership Agreement program are proceeding well."

(3) Group Communication. "*I had a conference call with members of the Rice Creek Watershed District (RCWD) this morning to discuss the*

Rule M requirements for this site". This is an example of a group communication by an entry-level engineer in the Case Study. Group communication occurred in settings both within and outside Metro Transit. Group communications were typically with a small number of people engage in discussions about specific agenda topics.

(4) Organizational communication. Organizational communication is communication that takes place within the organization. Entry-level engineers engaged frequently in communication with "internal stakeholders". Internal stakeholders were all employees of Metro Transit who had an interest in a particular project. I identified organizational communications in the Case Study that included "*Council Committee meetings, staff meeting, senior staff meeting, etc*."

(5) Public communication. In public communication, the entry-level engineers spoke or wrote to a group of people. Public communication happened when the engineers and public groups engage in dialogue about project specific matters that affected the public. Based on the Case Study data, "*public speaking events, media events and stakeholder meeting"* are a few forms of public communication that were used entry-level engineers.

Intervening Condition

The words we choose, how we use them, and the meaning we attach to them can cause many communication barriers. Based on Metro Transit entry-level engineers' project files, engineers encountered communication barriers including language barriers, emotional barriers and knowledge barriers.

(1) Language barrier. Communication becomes difficult in situations where people don't understand each other's language. The inability to communicate using a language is known as language barrier to communication. Civil engineers often work on projects that affect communities that speak languages that are different from their own. Delivering their message across language and cultural barriers, presented many challenges not ordinarily experienced when communicating to an audience that shares their native language. As a result, some employers in the Job Description data, preferred entry level engineers that were bilingual. For example, some job descriptions specified that entry level engineers "*Can write and/or speak Spanish/Vietnamese; Bi-Lingual in Spanish & English a plus; Required Language: English & Chinese; Bilingual in English (Fluently) and Mandarin (Native), Cantonese is a plus".* However, that requirement appeared to be more common in jobs that were with international firms or firms serving in diverse communities.

(2) Emotional barrier. The importance of communication depends on the mental condition of the parties. Situations often arise when people do not communicate effectively because they allow their emotions to impede their communication. Common emotional barriers regarding civil infrastructure projects are fear and distrust. Public projects are

especially newsworthy because they have local relevance and often embroiled with conflict. Misinformation and facts taken out of context can do a lot of damage to the public's trust in a project. Resultantly, at least one job description specifically called for candidates with emotional intelligence stating, "*Demonstrates the ability to read or sense other people's emotions and how they influence the situation of interest or concern; demonstrates empathy and organizational awareness*".

(3) Knowledge Barrier. Communicating professional knowledge is a key activity for today's civil engineer, including entry-level engineers. The efficient and effective transfer of experiences, insights, and knowledge among different experts and decision makers is a prerequisite for an effective civil engineering project team. Experts from various domains need to share their views and insights regarding a common goal in order to make decisions. In order to solve the problems that can impede decision making and the effective transfer of knowledge, the problem of knowledge asymmetry has to be resolved (Gratton and Goshal, 2002). To overcome the problem of knowledge barrier, an employer in the Job Description data detailed the need for entry-level engineers to "*develop documents, maps and other materials as required that explain information to those individuals who often do not have expertise in the area of transportation*". The Focus Group also suggested that "*Graphic tools will be introduced and used in the*

presentation course." This strategy as used effectively by entry-level engineers in the Case Study.

Action/Interaction Strategies

As part of the civil infrastructure development process, civil engineers are required to identify and invite the participation of interested persons. Communication is essential within the project team itself, and between the team and the rest of the organization as well as with the communities affected by the project. The Research data suggested that entry-level engineers chose communications methods that were appropriate for the type of information and for the recipient of the information. The need for adequate communication channels appeared to be extremely important in creating an atmosphere for successful project implementation.

Based on the data, entry-level engineers' communications appeared to be into four categories: technical, nontechnical, written and verbal. Effectively communicating technical messages to nontechnical audiences presents a challenge for most engineers. Employers hiring engineers recognize that challenge but affirms the need for this form of communication. In their Job Descriptions, they required that engineers are competent in this form of communication in the following term:

(1) Explaining complicated technical problems in simple non-technical language.

(2) Ability to communicate thoughts and technical ideas in an accessible way.

(3) Explaining complicated technical problems in simple non-technical language.

(4) Ability to communicate thoughts and technical ideas in an accessible way.

Civil engineering communication are to build consensus, and to do so, the recipients of their message have to be left feeling informed, and not ignorant. When addressing nontechnical audiences, entry-level engineers created ways to explain complex concepts that avoid references to background information, jargon, or short-cut thinking that they would ordinarily use. In review of the entry-level engineers' project files that comprise the Case Study data source, it was noted that engineers used varying tactics for simplifying and conveying their messages such as "*two-dimensional graphical communication, animations and simulations*". Simulation is a basis for expert opinion whiles animation is a representation of expert opinion. Simulations were used of the "*METRO Orange Line*" and the "*Mall of America Platform*" projects.

Entry-level engineers used tactical methods of communication that reflected the organization's strategic vision. It was identified from the Case Study data that communication was used as a tool to helps engineers keep track of the various activities and to make sure that the strategic vision was not lost in the later phases of the project. A tactical method engineers used was to communicate continually, the changing status of the projects to the other members of the project team. Engineers in the Case Study used methods such as "*Stakeholder meetings, Public Focus Groups project updates, City Council Meetings, and weekly project updates*" to keep stakeholders informed.

Engineers' communications reemphasized the importance of a joint, team effort in implementing their projects. Further, communication was required to reinforce the status of their projects relative to its lifecycle. Entry-level engineers kept their teams aware of the specific stage and the degree of strategic and tactical activities that were necessary to sequence the project from its current stage to the next phase in its lifecycle. According to employers in the Job Description data, entry level civil engineers are to, "*Communicates status, updates, and expectations to project stakeholders" and "Communicate regularly with officials at all levels within the City administration; City departments; local, regional, and state planners, engineers, and the public".*

For each reiteration of their message, the engineers needed to select their details carefully and then regroup and reorder them in the way that made the most sense to the interest and needs of their specific recipients. The entry-level engineers' formats for communicating their information also varied. The Case Study data described, "*reports, formal and informal written correspondence, in-person meetings, video conferencing, public meetings, conference calls, formal presentations, workshops and focus groups*" as among the format engineers used to conduct communications. The degree to which the communication is formal or informal depends on the contextual expectations of its participants. At times when communication is simply interactive, the expectation may be to build a working relationship. This type of dialogue requires interpersonal skills

(Friedman, 1987) and active listening (Brownell, 2009; Burstein, 2010). Unfortunately, these dialogues are not kept in the project files; however, I stumbled upon an email that represents interpersonal communication between project team members:

> *"Have you decided what time you will be going to lunch? I am thinking around 11:30 for me. Would you like to join?"*

This type of relational dialectics is an interpersonal communication skill that is essential for successful engineering practice. It is the sought of relation building that supports cooperation among team members.

Consequence Condition

It is a reasonable conclusion that consensus building and cooperation among stakeholders, or the lack thereof, are consequences of entry-level civil engineers' communicative efforts. A requirement in the Job Description data was that engineers had to have the "*Ability to negotiate mutually acceptable solutions and build consensus through give and take*". Communication processes are the key underlying mechanisms for establishing trust and cooperation. Permits are official documents that are granted when a governing authority trust that the actions proposed meet set standards. This is an example of such a cooperating action in one entry-level engineer's projects in the Case Study: "*This permit authorizes the applicant to grading in the south east quadrant of TH 13 and TH 77 in the city of Eagan as shown on applicant's plan sheet(s)".* Consensus building is an important part of a civil engineer's career. The following statements from the Case Study is an example of consensus among Council member to acquire land for an entry-level engineer's project:

> "*That the Metropolitan Council authorize the Regional Administrator to negotiate and purchase, at up to the appraised value, a 2/6-acre property from a private owner for a park-and-ride facility in the southwest quadrant of I-35E and County Road E in Vadnais Heights.*
>
> *Motion passed. Hearing no objection,* [redacted] *stated that this item could proceed to the full Council as a Consent item.*"

Communication engenders cooperative relationships, lays a basis for developing common values, and encourages continued interaction within project teams and among stakeholders. Sharing information among members of collaborative efforts also leads to information symmetry rather than information asymmetry (Hart and Saunders, 1997). The following is an example when an entry-level engineer shared information about specifications for a bench with the project design team:

> "*I would like to provide an update on the Blue Line and Northstar benches and the ADA design regulations. During our investigation, it looks like the Department of Transportation set bench regulations in 2006. We had the actual Target Field bench designer investigate the matter and why benches on stations built after 2006 do not meet this regulation. The designer reached out to U.S. Access Board. The Board stated that these requirements, that you and I have talked about during our meeting, do not apply on transit stations*."

Environmental stewardship and context sensitive solution offer a more-informed decision-making process. Effective decision-making requires information from all collaborating parties. Context sensitive solutions accomplishes this collaboration by instituting a mantra of informed consent, through active stakeholder engagement and open communication. The mantra is fundamental to any form of project planning and provides the basic building blocks upon which decisions are made and upon which consensus is built. Thus, as has been previously mentioned, civil engineering communication are to build consensus and cooperation.

Project Economics and Financial Management

The economics and financial management of a project plays a very vital role in its successful implementation. It is important to distinguish between the economics of a physical infrastructure and the financing plans for a project. The former refers to the cash flow representing the benefits and costs associated with the acquisition of the infrastructure; the latter refers to the cash flow representing the incomes and expenditures as a result of adopting a specific financing plan for funding the project.

In general, project economics and financial management are considered separate functions of project management since economics is related to design, construction, operations and maintenance of the infrastructure while financial management require knowledge of financial assets such as equities, bonds, notes, government appropriations, grants and mortgages, as well as accounting principles and practices. The separation of project economics and financial management does not separate the project acquisition from its financing requirements. As such, when evaluating project alternatives, combinations are duly considered. The coding paradigm comprising ‘Economics and Financial Management’ of civil infrastructure projects as found by this research is presented in Table 4.5.

Table 4.5. Coding Paradigm for Economics and Financial Management

Sub-Categories	Coding Paradigm	Categories
Budgeting	Causal Conditions	Economics and financial Management
Investment		
Value Engineering	Context	
Economic Justification		
Project Scope	Intervening	
Cost Estimating	Action/Interaction Strategies	
Financial Analysis		
Project Accounting		
Economic Sustainability	Consequences	

Causal Condition

When starting a project, it is important to know how much it will cost. Project managers are responsible for their budget estimates, and with so much uncertainty in projects, it can be one of the project managers' greatest challenges. A project budget is the total amount of authorized financial resources allocated for a particular project. The primary financial appropriation constitutes the necessary funds for implementing the project deliverables. The following is financial summary by an engineer for the "*I-35E - Co Rd E P&R*" project:

> "*The Capital Projects Life-To-Date Report, dated 4-30-11, indicates that Project No. 63111 has a Total Project Authorization (as of 1-1-2011) of $1,881,000. The Finance Department reports that when approved by the Council, $1,500,000 will be transferred to another project, leaving this project with a revised authorization of $381,000. The report also indicates that a total of $21,637 has been expended for work on this project through 4-30-2011, leaving approximately $360,00 available to begin the project. This funding currently appears to be sufficient to undertake the design portion of the project. Additional funding sources need to be identified as soon as possible to ensure funding is in place for the construction of the project*."

Employers in the Job Description data source were particular about including the skill to budget projects in their requirements. One Job description made it explicit that entry-level engineers should be able to "*complete Transportation Capital Improvement Program (CIP) budget activities*". Based on the Case Study data, entry-level engineers did participate in project budgeting activities such as, "*budget breakdowns, budget tracking and budget amendments*."

The core responsibility of a project manager is the successful execution of a project, within the estimated budget, time and quality standards. Though time and quality are equally importance in the lifecycle of a project, the project cannot move forward without the necessary amount of money determined by a well-planned budget. This is evident in one Metro Transit graduate engineer's statement, "*Based on my review there is adequate financial resources to perform the contract"*. According to the Focus Group, "*Engineers seek solutions to problems, and the economic viability of each potential solution is normally considered along with the technical aspects*". Investment into the project provides the financial resources for executing project. Project investments fall in two categorized: funding and financing. Funding tends to refer to reserves that are internal to the organization, while financing refer to an external source of capital. Job Descriptions data included statements such as, "*have the ability to apply for and capture State and Federal grant monies for funding large projects*" and "*assist with County's efforts in obtaining State/Federal funding for the project*". Graduate engineers in the Case Study conducted tasks such as "*transit element funding matrix*; *cash flow needs analysis*; and *financing grants"*.

A project's investment is structured by its cash flow. A private corporation which plans to undertake large capital projects may use its retained earnings, seek equity partners in the project, issue bonds, offer new stocks in the financial markets, or seek borrowed funds in another fashion. The Case Study showed, "*Federal funds, Local funds, UPA Grant $ Distribution, Regional Transit Capital funds, State Bonds, Counties Transit Improvement Board funds and Congestion Mitigation/Air Quality funds*", as some of the public investments.

Context Condition

Within every project, there are limited resources and unlimited wants. In order to keep the project within budget, managers must achieve the deliverables at their estimated values. That is to say, engineers have to make the most effective use of the financial resources available to the project. Cost reduction is the most stated criterion for a value engineering application. However, it is important to recognize that value improvement and sustainability are the real objective of value engineering, and that may not result in an immediate cost reduction but a life-cycle reduction in cots. The contextual conditions for project economics were value engineering and economic justification. According to the Federal Administration:

> *"Value Engineering (VE) means the systematic application of recognized techniques that identify the function of a product or service, establishes a value for that function, and provides the necessary function reliably at the lowest overall cost. In all instances, the required function should be achieved at the lowest possible lifecycle cost consistent with requirements for performance, maintainability, safety, security, and aesthetics." (FTA C 5010.1E, 2018, p. I-26).*

A Job task from the Job Descriptions was for engineers to "*apply value engineering principles to proposed utility designs*". A review of the Case Study data revealed the entry-level engineers performed value engineer activities such as, appraisals and analyses of alternates. This standard language in construction contracts make it reasonably probable of entry-level engineers to participate in value engineering and cost analysis activities: "*Approval of exceptions will be based on Engineer's judgement that alternative materials, methods and procedures are equivalent or superior to specification requirements. Engineer's rejection of exceptions will be final*." The entry-level engineers performed evaluations of designed infrastructure features, systems, equipment, and material selections for achieving essential functions at the lowest lifecycle cost consistent with required performance, quality, reliability, and safety.

Economic justification takes a broader view of the profitability of the project. In this example, a graduate engineer from Metro Transit in the Case Study provided the finding of a cost analysis that justified their recommendation:

> *"A cost analysis concludes that it would be more cost effective to demolish the Ragstock building and to lease another building for shelters operations."*

In an economic justification, the engineers include external effects such as environmental impacts, traffic impact and health impacts. External effects are valued by their economic opportunity costs. An economic justification is a comparison between a base case and the project alternative. Without this comparison, it would be impossible to assess whether the external effects are an improvement or not. For instance, the following example from the Case Study is a solicitation for pricing for environmentally friendly geothermal wells as a substitute heat source:

“***Geo-Thermal Heat Pump System***

Description: *Provide in lieu of a boiler and fluid cooler system a ground source geothermal alternative source serving the heat pump condenser water…*

Base Bid: *Boiler and fluid cooler system heat pump system as shown and specified in Bid issue documents.”*

This was from the Metro Transit Police Department project in which two entry-level engineers participated in developing its bid documents.

Intervening Condition

Project scope is the part of project planning that involves determining and documenting a list of specific project goals, deliverables, tasks, costs and deadlines. The Focus Group recommend that an outcome of the civil engineering curriculum should be the “*ability to scope a project*”. A well-written project scope statement describes the boundaries of the project. A comprehensive project scope defines the purpose of the project and the basis for defining project success. It provides the project team with information they need to design and deliver the project execution plan.

However, well-written, comprehensive project scopes do not guarantee immutability. Regardless how well written and comprehensive the project scope, change is an inevitable part of any project. As was previously discussed in Sustainable Project Management, project change orders are evidence of a change in the project scope. Scope creep occurs when the nature of required changes becomes large and significant, causing the project to overrun its budget and schedule. Scope creep, or the uncontrolled changes in a project's scope, is the tendency of a project to include more tasks than originally specified, which often leads to higher than planned project costs and an extension of the project end date. Changes in a project's definition and required outcomes without an increase in budget, resources or time causes missed deadlines and cost overruns. For example, the Orange Line is a project on which many entry level engineers have worked. In the Case Study, this Council action to amend the contract is due to additional coordination effort with other agency projects:

> "*That the Metropolitan Council (Council) authorize the Regional Administrator to execute a contract amendment to contract* [redacted] *Corporation in the amount of $932,675 for design and construction support services for the Orange Line project.*"

Creeping scope will have an impact on the time it takes to complete the project. Additional effort with no corresponding increase in resources will cause the project to suffer from an increase in project duration. An increase in the project schedule may have financial ramification for the project in terms of liquidated and unliquidated damages. Liquidated damages are not penalties, they are pre-determined damages set in the contract, based on a calculation of the actual loss the client is likely to incur if the contractor fails to meet the completion date. Liquidated damage is a standard clause in construction contracts. Though contracts were found to be a focal part of entry level engineers work it will be discussed later. Unliquidated damages are damages that are payable for a breach of contract, the exact amount of which has not been pre-agreed.

Action/Interaction Strategies

When analyzing the three data sources I found that entry-level engineers were required to and conducted project cost estimates. The ability to create an accurate project budget is a function of a cost estimate and is an essential skill for all civil engineer. Entry-level engineers as project managers at Metro Transit experienced the importance of cost estimation and budgeting from the initial phases of a project. The risk of project failure increases, and may be inevitable, when the project cost is not properly estimated. Once the engineer has finished the budget and the project starts, they implement cost control practices by regularly checking actual spending against their budget estimate. The cost control measures encountered in the Case Study were coded in this research as "*Project Accounting*". Some of the control measures taken by entry-level engineers included, expenditure tracking, funding tracking, financial progress reports and accounting summaries. Project Accounting also included measuring results, updating forecasts and continuous communication. It is an ongoing process that must commence at the onset of planning and remain in place throughout the project lifecycle.

One of the engineering management objectives is to do financial analyses of investment decisions. A financial analysis estimates the profitability of project alternatives from an investor's perspective. Since civil infrastructure projects are sponsored by both private and public entities, I provide a broad definition of profitability as the overage of project benefits over project costs. In the financial analyses of their projects, entry engineers compared the costs of the project alternatives to the expected benefit over the projects' lifespan. When the term "benefit" was used in the data, it referred to the positive change in external effects that can be attributed to the project.

Consequences Condition

In all economies there is created capital such as roads, buildings and bridges and there is natural capital such as land and water. In this research, I used (Elliot, 2005) measure of economic sustainability to determine the degree to which created and natural capital are complementary goods. On one end of the spectrum sustainable created capital is complementary of the natural environment and on the other end, created capital is a substitute of the natural environment. Project procedures are interwoven around its economic and financial management in order to constitute an economically sustainable project. For example, accounting practices such as the ones encountered in the Case Study including, "*Authorizations and Expenditures Tracking, Draw down memo, Subrecipient invoicing, Financial progress reports, Project Accounting Summary, Transit element funding matrix*" are a set of procedures that are meant to maintain the project's schedule of values.

The amount of available cash, in most cases, dictate the project duration, type of resources used, and operations and activities within the realm of the project. In the case of project budgets, a miscalculation, poor judgment or a lack of proper oversight might result in the collapse of the whole endeavor. However, a well-managed project can result in economic sustainability by minimizing the use of natural capital. Financial and economic benefits can result from reduced use of materials, improved pollution prevention, reduced carbon emissions, payment for environmental services, and better labor and community relations.

Rules for sustainability

The term “Rules for Sustainability” is about governance for sustainability, because law provides essential tools and institutions for governing sustainably. Civil engineering and law may not seem to have much in common, but laws affect every profession in some way. Civil engineers deal with highly technical concepts, designs and products, and the rules affecting an engineer’s work can be as complex as the work itself. I define rules as to include, laws, regulations and codes that the practice of civil engineering involves. Civil engineers must meet certain standards of their profession and comply with applicable rules. Issues of the environment, land, bonding, licensing, contracts, labor relations, health and safety, insurance and building codes are common topics involved in civil engineering rules. My analysis of the three data sources found that entry-level engineers were required to be proficient in the research and application of the codes, specifications, standards, laws, regulations, policies and procedures that affect civil engineering practice. Job Descriptions stated that engineers would, “*Research and review deeds, ordinances, municipal, state and federal codes to ensure compliance*”. The Focus Group specified that civil engineering students must, “*Know how to find regulations and state and federal codes*”. In the Case Study, Entry-level engineers performed “*City ordinance investigations, examinations of International building codes, Federal regulations and best practices studies and Analysis of State Statutes*”.

In my analysis of the Case Study data, I found that the laws most commonly encountered by entry-level engineers had to do with environmental, construction, real property and building codes.

(1) Environmental Law. Environmental law is the collection of laws, regulations, agreements and common law that governs how humans interact with their environment. The purpose of environmental law is to protect the environment and create rules for how people can use natural resources. Environmental laws cover a wide range of topics including the following: Air Quality, Water Quality, Waste Management, Contaminant Cleanup, Chemical Safety and Hunting and fishing. The Job Description and the Focus Group offer these respective statements on entry engineers' knowledge attainment of environmental issues: "*Thorough understanding of the environmental rules that apply to construction projects; and Skills necessary to identify the actions needed for a thorough environmental analysis and mitigation*.

(2) Construction Law. Construction law is the combination of all of the areas of law that apply to construction work. The practical area and topics in construction law include contract law, employment law, approvals, torts, workers compensation, dispute resolution and occupational safety.
The Focus Group recommend that the civil engineering curriculum must "*Introduce the student to the technical and legal documents that are used in the construction industry*". The Job Description call for entry-level

engineers to have, "*Knowledge of Building code and construction regulation*" and to "*Administers agreements for construction*".

(3) Real Property Law. Real property law is any rules that dictates who can use a property and how it can be used. Real property law also governs the use of any structures on the land, and how materials below the land can be used and by whom. Real property law is statutory, enacted by a legislative body, or regulatory, enacted by a governmental administrative agency. Since real estate necessarily stays in one location, most real estate law is state law. However, federal law does have a role. For example, if property was purchased with federal funds. Since real property law is about the use and ownership of real property, it necessitates the delineation and demarcation of real property. This require knowledge of land surveying. An example of a Job Description requiring such knowledge: "*Work with government agencies and public authorities as required to provide support for land surveying and mapping*". It, therefore, an additional job requirement to, "Reads and interprets survey data, legal description, government standards and codes" for projects such as the *I-35E & CR 14 park-and-ride* from the Case Study. As was outlined by the Focus Group, engineers had to become familiar "*with the legal side of the project by putting together documents such as easements, restrictive covenants, license agreements and more*".

(4) Building codes. Building codes are a set of rules that specify minimum standards for the design and construction of buildings and other

structures. The complete process of planning, design, construction, and operation of buildings and other structures are guided by various standards, guidelines, design aids. Therefore, the Focus Group expect civil engineering students to "*be able to interpret ordinances, codes and specifications*", in order to use them in these different applications.

Countries or regions establish codes, and they take account of regional variations, such as climate and seismic risk. Consequently, Employers in the Job Description data set expect entry-level engineers to be "*Familiar with governing State and National codes and standards*".

The main purpose of codes is to protect public health and to ensure safety and general welfare as they directly govern the construction and occupancy of buildings and other structures. The codes become law of a particular jurisdiction when formally enacted by the appropriate governmental authority.

The coding paradigm comprising 'Rules for Sustainability' of civil infrastructure projects as found by this research is presented in Table 4.6.

Table 4.6. Coding Paradigm for Rules for Sustainability		
Sub-Categories	**Coding Paradigm**	**Categories**
Environmental Impacts	Causal Condition	Rules for sustainability
Transportation Impacts		
Utility impacts		
Unstructured Problems	Context Condition	
Regulatory Knowledge		
Statutory Knowledge		
Project Complexity	Intervening Condition	
Project risk		
Impeding Factors		
Legal Training	Action/Interaction Strategies	
Legal Research		
Legal Documentation		
Legal Compliance	Consequences	

Causal Condition

(1) Environmental impacts. Entry-level engineers from the Case Study had to consider the environmental impacts of infrastructure projects. Infrastructure projects are presumed to cause environmental problems ranging from excessive consumption of resources to the pollution of the surrounding environment. An analysis of the Case Study data found that construction projects managed by the entry-level engineers

were typical of all construction projects. Their activities caused adverse impacts on the natural and social environments including for example, "*tree removals, air quality, water quality, soil erosion, use of land, noise, visual impacts*".

(2) Transportation Impacts. Entry-level engineers engaged in studying the impact the built environment had on transportation. These studies were conducted with the aim of resolving some of the impacts. For example, the Case Study established entry-level engineers' engagement in studies such as "*pedestrian and bicyclists impact, traffic congestion, access impacts and parking impacts*". The engineer's construction projects, like most construction projects, sometimes alter access and disrupt pedestrian and motorist travel patterns.

(3) Utility Impacts. Many of the entry-level engineers' projects included utility relocation. Utility companies typically deal with a single entity such as a municipality or State Department of Transportation for right-of-way because it is more efficient than dealing with a myriad of private property owners. In such cases, frontage to service customers and access for facility maintenance are coincidental with the street or highway. In cases of relocation when the utility company has to affect privately owned land, the impact on private property ownership can be significant. As a result, private landowners are often reluctant to allow such use of their property. The following proposed tasks from job descriptions demonstrates employers concern with utility impacts:

(1) Investigations to identify existing utilities and determine scope of potential conflicts.

(2) Analyze roadway design plans and utility construction proposals to evaluate resolution of conflicts with existing and proposed utilities.

(3) Perform utility relocation coordination and inspection.

However, property rights law and the issues surrounding public use of private property flow from Amendments 5 and 14 of the U.S. Constitution. The former addresses just compensation and the latter discuss due process. Eminent domain gives utility companies the right to expropriate private property for public use. The use of eminent domain by utility companies require payment of just compensation and that the taking of private property is for a public use.

Context Condition

Unstructured problems within the project such as, community norms and values and the organization's decision-making process influenced the rules that entry-level engineer used for their projects. Uncertainty exists in everything civil engineers design due to such circumstances as loading dynamics, variations in material dimensions, vibrations and impacts, material decay, high variability in mechanical properties and unknown building sites. Engineers compensate for these uncertainties in their design by using codes and other rules. The circumstances of the project determine the codes and rules used. For example, the use of specifications to address uncertainty such as variability in materials was common in entry-level engineers' projects. For example, the following is standard language in construction contracts for independent testing inspections of materials and methods. This language was common in entry-level engineers' construction projects:

> "*CAR may direct CONTRACTOR to arrange for ITL to provide "TESTING AND INSPECTION" services. A cash allowance, "Testing and Inspection Allowance", has been included on the Bid Form to reimburse CONTRACTOR for the cost of ITL services when directed by the CAR to employ and pay an ITL to provide "TESTING AND INSPECTION" services.*"

Another contextual factor is community characteristics. The community that is home to the projects may have unique cultures or rights that dictate the rules by which stakeholders must abide. For example, the environmental and property rights laws incumbent upon indigenous community may be different from other communities. Though engineers who worked on the "*Better Bus Stop*" project, mentioned earlier, coordinated some of their work with the Native American community, there were no unique rules by which to abide. However, the Metropolitan Council's decision-making process affected how rules were enacted within a project.

The statutory and regulatory knowledge level of project manager plays a significant role in the implementation of the rules. More experienced entry-level engineers were better able to navigate the procedural requirements. In some instances, these engineers were able to plan their projects where some of the procedures were not necessary. For example, one engineer from the Case Study was able to coordinate her project with a city project and thus, negate the city approval process:

> *"Design sidewalk connection from Naples St NE to boarding area at 95th Ave park and ride in Blaine. Would work best by coordination with City of Blaine project to connect to sidewalk along Naples St."*

Intervening Conditions

Complexity, risk and Impeding factors were found to shape, facilitate or stain the strategic use of rules for projects. As was discussed in Context Sensitive Design and project management categories, project complexity can come in the forms of structural complexity, temporal complexity and technical complexity. The complexity of the project determines the variations of rules and the number of rules that are needed to mitigate the complexity. Also, as was discussed, project risks can vary from low to high. The amount of risk, for example the likelihood of encountering contaminated soil shaped the strategies used for the project. For example, the more complex projects that were managed by graduate engineers included Response Action Plans (RAP) to address potential soil contamination. This is evident from excerpt from a Minnesota Pollution Control Agency cover letter for a draft RAP for the "*Heywood Garage*" project:

> *"The enclosed DRAP establishes procedures that will be used to monitor and respond to the presence of petroleum-impacted soil if it is encountered during redevelopment on the captioned site (Site)."*

Action/Interaction Strategies

The risks, impeding factors, and unstructured problems that come with infrastructure development are avoided, mitigated and safe guided against by using various laws, specifications, codes, etc. These rules are administered through specifications, the execution of contracts, the procedural development of environmental statements, etc. Based on this research, it appears that entry-level engineers must have at least rudimentary knowledge of the rules related to civil engineering. This study found that these engineers were expected to and did perform research and administratively work on the necessary compliance documents for their projects. The following are examples of incidences from the three sources of data:

The Focus Group recommend that in order to prepare civil engineering students of engineering practice the curriculum must –

(1) Introduce the student to the technical and legal documents that are used in the construction industry.

Job Descriptions call for entry-level engineer to have –

(2) Knowledge of federal and state laws and regulations pertaining to design, construction, and the environment.

A justification for hiring intern civil engineers explains that the interns are needed to –

(3) Assist senior design personnel in developing and completing contract documents.

This research also found that Metro Transit supported entry-level engineers' learning by providing them training, education and development opportunities. For example, engineers who required training on environmental laws were able to do so through the Department of Transportation; those who wanted to become more familiar with contract law were reimbursed for training with the private sector; and those interested in real property law had many options available to them including the Federal Highway Administration.

Consequence Condition

The research data show that entry-level engineers' projects achieved legal compliance based on the permits in the Case Study. For example:

(1) This permit authorizes the applicant to grading in the southeast quadrant of TH 13 and TH 77 in the city of Eagan as shown on applicant's plan sheet(s).

(2) Section 404 Wetland Permit

(3) Section 106 Programmatic Agreement

(4) Right-of-Way Permit

Considering project risks, impeding factors, unstructured problems, and sustainability together is about realizing project resilience. Putting these components together where they can share tools, leverage people and develop a working partnership makes project compliance sense. The legal compliance of rules is a viable tool for the effective management of infrastructure project risks. The economic, safety and legal risks associated with infrastructure project impacts are directly related to its impeding factors and unstructured problems.

The effectiveness with which engineers and organizations are identifying, managing and disclosing these risks is what makes a project sustainable.

Ethical Conduct

Engineering is something that engineers do, and what they do has profound effects on others. Professionalism and ethics in the workplace are the guiding principles that individual employees and organizations has established. Since ethics is a system of accepted beliefs that controls an engineer's behavior, everything an engineer does is guided by his/her ethical compass, particularly on projects that affect the general public. The coding paradigm comprising 'Ethical Conduct' in civil infrastructure projects as found by this research is presented in Table 4.7.

Table 4.7. Coding Paradigm for Ethical Conduct

Sub-Categories	Coding Paradigm	Categories
Responsible Site Development	Causal Conditions	Ethical Conduct
Sensitive Design		
Environmental Compliance		
Sustainability		
Problem Solving		
Project Management		
Project Delivery		
Legal Compliance		

Table 4.7. Coding Paradigm for Ethical Conduct (Cont.)		
Sub-Categories	**Coding Paradigm**	**Categories**
Workplace Ethical culture	Context condition	Ethical Conduct
Professionalism	Intervening Condition	
Decision-making judgement		
Workplace ethical policies	Action/Interaction Strategies	
Workplace ethical Climate	Consequences Condition	
Moral Sensitivity to Sustainability		

Causal Condition

Responsible Site Development, Sensitive Design, Environmental Compliance, Sustainability, Problem Solving, Project Management, Project Delivery, and Legal Compliance, all of which has been discussed in this dissertation, individually or cumulatively, present cause for ethical conduct. The purpose of engineering ethical conduct is to increase the skill of moral judgment. Moral responsibilities are derived from the special knowledge one possesses, such as professional knowledge that is crucial to an aspect of another´s well-being (Whitebeck, 1998). The moral responsibility refers to the general values of humanity, dignity and of the quality and the improvement of the human life (Lozano, 2003). Its principal aim is to improve the skill to think critically about moral aspects in the professional area. Responsible site development, sensitive design, environmental compliance, sustainability, problem solving, project management, project delivery and legal compliance all presented the entry-level engineers with inarguable and consequential opportunities for critical moral thought and decision-making.

Job Descriptions require that entry level engineers "*Review Contract documents, engineering plans, and technical specifications to ensure compliance with governmental regulations*". A hiring justification in the Case Study for an entry-level engineer read:

> "*Attention to sustainability has become a critical element to any successful business. This internship will provide valuable experience in a successful, growing and proven sustainability program. In support of Metro Transit's Sustainability Mission, collect, analyze, and report on data, solicit support and share results, see solar projects being built, and create and manage new projects*."

Because of these opportunities for critical moral thought, the Focus Group called for the curriculum to "*Introduce students to the manner in which land development engineers must consider planning, environmental, and sustainability issues*". Without a sense of ethical responsibility, environmental stewardship (i.e., responsible site development, environmental compliance and sustainability) as efficient, effective management inevitably falls prey to human ignorance and human hubris. Context Sensitive Design brings a unique opportunity for proactive integration of ethics into design (Van den Hoven, 2008). Context Sensitive Design draws on ethical conduct to identify values that are relevant for civil design. The Focus Group participants recognized this opportunity for proactive integration of ethics when the recommended those educators "*should teach the core design courses but also include constraints and societal effects*".

Ethical conduct also weighs heavily on project management. Project management is driven by decisions. Some decisions require deep thought because they involve people, resources and the environment. And, sometimes these factors are in conflict, creating a dilemma and perhaps significant risks. As a result, the Focus Group concluded that undergraduate civil engineering student must graduate with the "*ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability*". Also, making the best possible decisions when problem solving or the delivery of projects and the methods for legal compliance require professional ethical conduct.

Context Condition

In a study on workplace culture by Kaptein (2011), the results illustrate that the ethical culture of work groups has a negative relationship with the frequency of observed unethical behavior within work groups. Ethical culture is the part of an organization's culture that drives beliefs, norms, and actions of employees. An important element of ethical culture is the tone at the top. Tone at the top refers to the ethical environment that is created in the workplace by the organization's leadership. An ethical tone creates the basis for standards of behavior that become part of the code of ethics. Based on the Case Study data, formal training as a distinct ethical culture define a particular Metro Transit culture. Entry-level engineers were, as are all employees, required to take workplace behavioral training such as, "*professional workplace training, respectful workplace program, fraud, and Metro Transit Guiding Principles*". These courses focused on minimum standards of ethics and expectations. The minimum expectations are respect for others, adherence to rules, honesty, trustworthiness and professional ethics.

Intervening Conditions

In this research, I was able to identify professionalism and decision-making judgement as two intervening conditions that shaped the entry-level engineers' ethical conduct. Professionalism can be defined as the possession and autonomous control of a body of specialized knowledge and the qualities that encompasses a profession. The American Society of Civil Engineers and State licensing boards provide engineers fundamental principles and canons for practicing civil engineering. Though entry-level engineers are not typically licensed, they are expected to follow these ethical practices.

As was previously stated, civil engineering work include a high level of uncertainty. Ethical issues are present in uncertain conditions where multiple stakeholders, interests, and values are in conflict. Entry-level engineers appeared to engage in discretionary decision-making behavior that had consequences such as contract management. In situations where the entry-level engineer was given autonomy to act, reactions to an ethical dilemma was determined by his or her cognitive moral development stage. However, I was not able to assess the moral development of the engineers, as the data source is not conducive to directly observing or measuring their ethics.

Action/Interaction Strategies

Institutional policy has a strong impact on the level of organizational anomie. I observed that at Metro Transit, a division of the Metropolitan Council, policies regarding ethical and law-abiding conduct were implemented with the same rigor as those addressing other areas of the organization’s operations. The code of ethics outlines the ethical principles that govern decisions and behavior at the organization. They established expectations relating to appropriate ethical conduct for all Metropolitan Council employees, established guidelines for acceptable workplace behavior and encourage an environment of respect and dignity.

Metro Transit policies required that all employees, officers and directors comply with all laws, rules and regulations applicable to their business. According to Metro Transit’s policy, “*integrity begins with complying with laws, rules and regulations when conducting business*”. Further, each employee is required to understand the organization’s policies, laws, rules and regulations that apply to their specific roles. When an engineer is unsure of whether a contemplated action is permitted by law or Council policy, they were to seek advice from the resource expert in the offices of Procurement, Human Recourse and the General Counsel. This is evident in the following correspondence by an entry-level engineer to the Procurement office:

“I have talked to [redacted], because [redacted] is out of the office until June 27. [redacted] stated that we would need the CIM for a sole source with a price this high. Thus, i have started working on the sole source and I have some questions with regards to both the sole source and CIM.”

Consequence Condition

Organizational norms and values dictating how ethical problems should be addressed create an ethical climate, which exerts a powerful impact on employee motivation and capacity for ethical conduct (Martin and Cullen, 2006). Ethical climate in organizations, as a product of organizational culture, refers to the moral atmosphere of the work environment and the level of ethics practiced in such issues as responsibility, accountability, communication, regulation, equity and trust (Martin and Cullen, 2006). Initiatives such as Thrive 2040 provides Metro Transit the opportunity to shift towards more equitable transit in the Twin Cities. According to the Metropolitan Council:

> “*The Thrive MSP 2040 plan places new emphasis on the importance of engaging communities equitably, to intentionally engage both historically underrepresented and underresourced communities such as communities of color, cultural communities and immigrants, people with disabilities, low-income individuals, the elderly, and youth in a way that more directly addresses existing social inequalities*”

The Council’s three guiding principles of, “*integration, collaboration and accountability*” appear to be steps towards workplace ethical climate.

Based on some of the projects and programs in the Case Study, there appeared to be a shift to moral sensitivity to sustainability at the Metro Transit. Example:

(1) Metro Transit has an established energy conservation and sustainability program. This internship will help support the agencies commitments to implement energy saving/producing projects and keep current with sustainability reporting requirements, utility usage, and goal progress.

(2) The E & F Sustainability and Energy Work Group leads Metro Transit's sustainability initiatives as empowered by Thrive MSP 2040 and as required by State Statute and Executive Orders. Focusing on reducing GHG emissions and energy consumption as well waste and water management that promote and demonstrate environmental stewardship.

Moral sensitivity to sustainability refers to the collective understanding, regard and care an organization have toward ecological and social sustainability. It is characterized by the organization's level of moral awareness and empathy.

Selective coding

The selective coding was a process of integrating and refining the findings from open and axial coding. Integrating the categories to develop a theory was similar to axial coding, but the level of analysis was more abstract, and the ensuing theory is representative of a collective voice. The first step in selective coding and in developing the theory is finding the story line (Straus and Corbin, 2015). Based on this research, the storyline began with the assertion that entry level civil engineers' work comprises of 'Sustainable Civil Infrastructure Projects'.

My intent with selective coding was to highlight and explain the generated theoretical framework using descriptive narrative. The explanation of the theoretical framework is prima facie to a description of the core category. Using the selective coding model and propositions I developed, the literature reviewed here represents the seven overarching categories that emerged from the study of entry-level civil engineering practice and are foundational to the core category that is 'Sustainable Civil Infrastructure Project'. The seven categories were Context Sensitive Design, Environmental Stewardship, Economic and Financial Management, Sustainable Project Management, Effective Communication, Rules for Sustainability and Ethical Conduct.

Core Category

Figure 4.1 is a diagrammatic representation of the core category developed as a result the open and axial code findings. It represents the collective work experiences of entry-level civil engineers in this study. The figure is helpful in defining the types of interactions that are necessary to characterize progress towards the core category, 'Sustainable Civil Infrastructure Projects'.

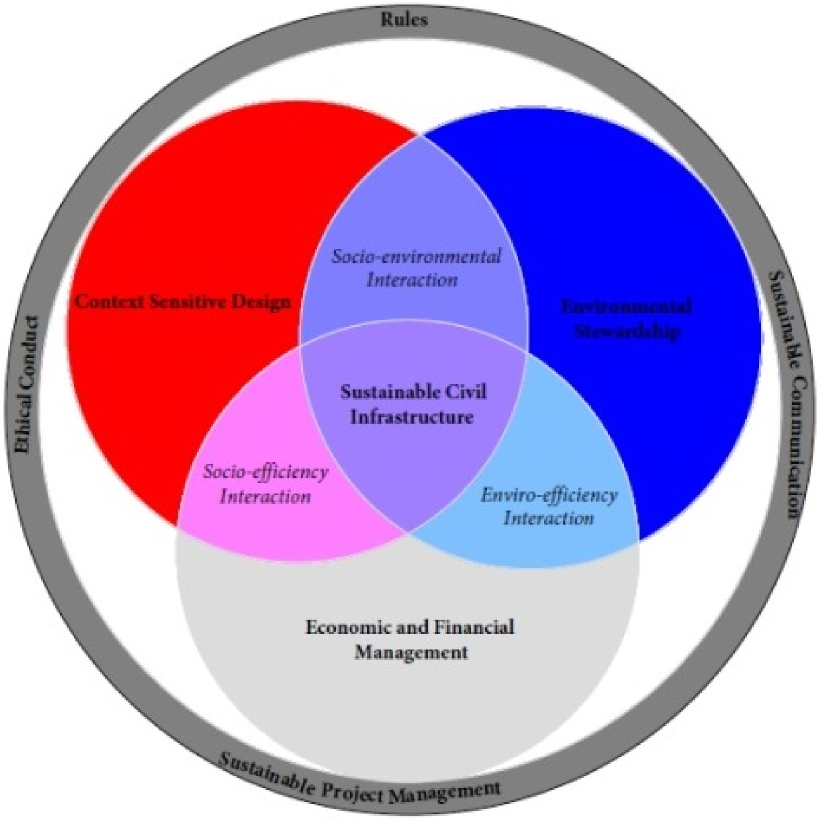

Figure 4.1. Core Category development

The phenomena in this study are the dynamic, interactive, interconnected concepts that influence the development of Sustainable Civil Infrastructure Projects. Sustainability focuses on the interaction between a given project and the social, environmental, and the economic dimensions of the system enclosing it. The three intersecting circles illustrates sustainability (Azapagic and Perdan, 2000). Each inner circle in this depiction represents one of the three “legs” of sustainable civil infrastructure projects, i.e., societal aspects (Context Sensitive Design), environmental aspect (environmental stewardship), and economic aspect (economic and financial management). The outer circle, comprising of Sustainable Project Management, Effective Communication, Rules for

Sustainability, and Ethical Conduct, aims to align the socio-environmental, enviro-efficient, and socio-economic interactions to achieve optimally sustainable civil infrastructure projects. It is worth noting that maximum alignment and thus, maximum sustainability is achieved, at least theoretically, when the three inner circles are in superposition and all four circles are equiradial. However, maximum sustainability and achieving it is not the focus of my research.

Socio-environmental Interaction

Context Sensitive Design as well as environmental stewardship encompass both societal and environmental aspects. Context Sensitive Design is a collaborative process that involves stakeholders in the development of civil infrastructure that are appropriate to their context, preserve a community's scenic, aesthetic, historic and environmental resources, and satisfy safety and mobility criteria. Implementing context sensitive solutions supports all of the triple bottom line sustainability principles by ensuring that environmental resources, community values, and economic context of a project are all considered during project development (FHWA, 2004). Bryson, Quick, Slotterback and Croby (2013) quotes Wildavsky (1979) saying:

> The decision-making and design science literatures emphasize the importance of understanding the problem or challenge to be addressed in such a way that it can be solved, the wrong problem is not solved and solutions do not create the problem that they were meant to solve (p. 25).

Participation processes must fit the context in which they are taking place. The general context includes broad social, demographic, political, technological, physical, and other features and trends (Bryson et al., 2013) that characterizes a community. In furtherance of these ideas, Context Sensitive Design requires early involvement of stakeholders and a continuous commitment to public involvement, flexibility in exploring new solutions, and an openness to innovative ideas. Stakeholders play an important role in identifying issues and associated solutions that may better meet and balance the needs of the community. Context Sensitive Design and sustainability are complementary approaches to the same endpoint. The Context Sensitive Design framework is well-suited to accommodating sustainability considerations. It addresses the need for a more systematic and all-encompassing approach in project development, which recognizes the interdependency of all, stages and views them along a continuum (Transportation Research Board, 2004).

While Environmental Stewardship shares some traits with Context Sensitive Design approaches, they are not the same. Instead, Context Sensitive Design and the environmental review process are complementary decision-making processes. Both processes are comprehensive in nature, but their focus is generally different. Underpinning Environmental Stewardship philosophy of sustainable development is that, “the natural resources belong to all humans whose aspiration to higher standards of living should not be rendered limited” (Sikdar, 2003, p. 1928). A healthy ecosystem is the foundation for many local economies, sustaining and enhancing human life with services ranging from food and fuel to clean air and water (McGinnis and Ostrom 2012). However, infrastructure projects can have major impacts on local ecosystems. For example, the "*O&M Facility Expansion*" project from the Case Study*,* if not monitored could have adverse effects on the air quality in the local community.

The ecological impacts of civil infrastructure projects have been the focus of many debates on environment development. However, the realization that in addition to or in conjunction with these ecological conditions, there are social conditions that influence the ecological sustainability or unsustainability of the people-nature interaction (Conrad and Daoust, 2008). In recognition of this new ethic, the focus of contemporary stewardship lies in creating positive social values through social engagement (Welchman, 2012). "Because stewardship is a role, its moral justification is a function of its overall consistency with [local] common moral norms, including norms of justice, tolerance, and equity in the distribution of social benefits and burdens" (Welchman, 2012, p. 10). Stewardship in the case of the "*O&M Facility Expansion*" project meant an analysis of the air quality. Minnesota statute requires the Minnesota Pollution Control Agency to analyze and consider cumulative levels and effect before a permit for a facility in the described area is issued. DeWitt (2006) suggest that, "Stewardship dynamically shapes and reshapes human behavior in the direction of maintaining individual, community, and biospheric sustainability in accord with the way the biosphere works" (p. 151). Stewardship requires that Scientia (knowledge) Ethics (what ought to be) and Praxis (doing) must interact together not individually (Berry, 2006). To accomplish this interaction, the "*METRO Orange Line*" project in the Case Study for example, used social engagement as a collaborative tool for social learning, for the creation of shared meaning and values to guide a stewardship ethic and inform socioecological interrelationships (Bennett, Whitty, Finkbeiner, Pittman, Bassett, Gelcich, and Edward, 2018). The engagement occurred in two phases of the project, “Public engagement in design” and “bus service restructuring plan”. The Orange Line stations are geographically disconnected from each other because of their location along a major freeway. Therefore, engagement was organized around individual station areas and was contextual to the nearby communities.

Context Sensitive Design has an opportunity and potential to influence the enviro-effectiveness of our civil infrastructure positively. Enviro-effectiveness generate cyclical revitalization of materials to maintain their status as resources. A central component of the enviro-effectiveness concept, “cradle-to-cradle design” (Braungart, McDonough and Bollinger, 2007) provides a practical design framework for creating infrastructure systems in a positive relationship with ecological health and long-term economic growth. For example, the “*Metro Transit Police Department*” project from the Case Study used Buildings, Benchmarks and Beyond (B3) guidelines for its design. B3 guidelines use life cycle analysis to quantify and minimize the environmental impact of building materials, which have significant effects on global warming, air pollution, water pollution, energy consumption, and waste.

The cradle-to-cradle concept represents a design strategy to implement the approach of enviro-effectiveness. Cradle-to-cradle is a “metabolism” which “allow maintaining or increasing the quality and productivity of materials through many cycles of use rather than aiming at reducing waste” (Lindner, Braungart and Essig, 2019, p.2). The relation of enviro-effectiveness and enviro-efficiency (discussed later), “is an important goal in design for environment, as the relation between long term strategy and short-term activities are important in every product development project.” (Jakobsen, 1999, p.104).

Enviro-efficiency Interaction

In contrast to enviro-effectiveness, "doing the right things", enviro-efficiency is about "doing things right”. In combination, they have the potential to do the right thing and doing it efficiently. As a measure of enviro-efficiency, the ecological environmental impacts that occur throughout the entire infrastructure lifecycle are put in relation to the costs for the end customer.

Enviro-efficiency =

$$\frac{environmental\ performance\ throughout\ the\ entire\ infrastructure\ lifecycle}{total\ costs\ of\ ownership}$$

Civil infrastructure systems involve the design, analysis, and management of infrastructure supporting human activities, including, electric power, oil and gas, water and wastewater, communications, transportation, and buildings that make up urban and rural communities. From an economic perspective, civil infrastructure projects have societal benefits such as lower production costs, increased output, increased economic growth and increased productivity. However, the construction of civil infrastructure projects has been accused of causing environmental problems ranging from excessive consumption of global resources to the pollution of the surrounding environment. Among the problems attributed to these projects include, biodiversity loss, deforestation, desertification, groundwater contamination, soil erosion and air pollution. Resultantly, both regulatory bodies and customers now demand environmentally responsible business practices; and thus, environmental accountability has evolved from a social responsibility issue into a strategic imperative (Hohnen, 2007). If policy to improve the environmental performance of civil infrastructure project is to be further developed, the impact of various characteristics on environmental efficiency needs to be identified.

Enviro-efficiency is the improved environmental performance of an infrastructure through the selection of low-impact material, reduction of material usage, reduced energy consumption, reduced waste and pollution during its lifecycle. Metro Transit, the focus of the Case Study, has a sustainability program that hires civil engineering interns and graduate engineers for most of its projects. The program, through its projects, researches and implements sustainability measures such as "*geothermal energy, LED systems, energy reduction, water recycling, material recycling, etc*". Using enviro-efficiency to measure sustainability require overcoming different challenges in the context of attaining both economic and ecological goals. These challenges include activities on the environment (e.g. resource consumption, pollution emissions, waste); effects of resource productivity on the economy (e.g. economic efficiency); impacts of environmental degradation on economic productivity (e.g. reduction in absorptive capacity, loss of forest cover); and the effects of environmental improvement on society (e.g. congestion costs, improvement in wellbeing, social costs) (United Nation, 2009). Inputs used in the production process can have impacts, either positive or negative, on the environment and environmental efficiency aims to take account of these impacts in ranking economic units according to their level of efficiency (Graham, 2004). Efficiency consist of both technical, which refers to the ability to produce maximum output from a given set of inputs, and allocative efficiency, which refers to the ability to optimize on the use of inputs given their respective prices (Graham, 2004). To optimize inputs entry level civil engineers must know how to analyze projects' costs and funding options, economic return on investment and risk; and knowledgeable about concepts of finance and economics within a civil engineering project. For instance, many of the Job Descriptions required entry level engineers "*to perform cost and schedule estimates for projects, apply value engineering principles to proposed designs, reviews completed work orders and cost data to assure conformance with plans and acceptability of construction charges, etc*." The Focus Group believed students must be able to "*conduct value engineering studies and project costs comparisons*". In the Case Study, engineers often conducted detailed cost estimates and economic analyses for their projects. The following is a position purpose statement for a sustainability entry level engineering at Metro Transit:

> "*Assistance to the E&F department to provide additional staff hours to collecting data, evaluate project needs, Management of projects and programs that support the team objectives. The duties begin with defining the effort to be undertaken, determining the payback and often continue with data analysis to track and report progress. Specific projects for this*

position are as follows: lighting retrofits, lighting control audits, Air Compressor ECO implementation, energy dashboard development, sustainability documentation and guideline development."

It is evident the purpose includes payback analysis as a component of the position tasks.

Socio-efficiency Interaction

In order for engineering to realize its full potential to benefit society and individuals, it is important that engineers are socially responsible (Bielefeldt and Canney, 2014). Social responsibility is an ethical theory that individuals and collective groups have an obligation and duty to perform to benefit society, the environment, and the economy (Frederiksen and Nielsen 2013; Garriga and Mele 2004). For this research, I define socio-efficiency as the intersection of economic and social impacts of civil infrastructure projects. The socio-efficiency of a civil infrastructure project is the relation between its value added and its social impact (Saxena and Khandelwal, 2009). As a measure of socio-efficiency, we relate the social environmental impacts that occur throughout the entire infrastructure lifecycle to the costs for the end customer. This relationship is sometimes in the form of the following ratio:

Socio-efficiency =

$$\frac{social\ benefit\ throughout\ the\ entire\ infrastructure\ lifecycle}{total\ costs\ of\ ownership}$$

Socio-efficiency, however, occurs when the ratio equal one or at an output where marginal social benefit equals marginal social cost.

"Total cost of ownership is a metric of managerial and investment strategies, including sustainability initiatives, for capital projects in a portfolio context" (Pearce, Bernhardt and Garvin, 2010, p. 3159). According to Pearce et al. (2010), the total cost of ownership is a metric for comparing project alternatives as part of planning or design, identifying cost drivers for design changes and optimization, or as a screening criterion for project funding. Included in these costs are design cost, administrative cost, capital expenditures and operating costs.

However, in sustainable civil infrastructure projects external costs, or externalities, are also considered. An externality is any effect on people not involved in a particular transaction. Loud automobiles, polluted air, and polluted rivers are all examples where a civil infrastructure transaction between two parties harmed other people. The following is an excerpt from the "*METRO Orange Line*" project that considers the impacts and benefits of one of the stations in the project:

> "*Environmental impacts and benefits related to Lake Street Station infrastructure are being considered under the larger scope of the 35 Lake Transit Access Project, which includes roadway, transit, and bridge improvements along I-35W from 46th Street to I-94. The Federal Highway Administration (FHWA), in cooperation with MnDOT, is preparing an Environmental Assessment (EA) for the 35 Lake project, and FHWA has requested that the Federal Transit Administration (FTA) become a Cooperating Agency. The service impacts and benefits of the Lake Street*

Station will be considered under the scope of the Orange Line environmental process."

Nevertheless, external effects are not necessarily negative. For example, transit creates an important positive externality for those who cannot afford private transportation. Generally, a negative externality like pollution creates a marginal social cost that is higher than the marginal private cost. Similarly, a positive externality like beautification projects such as the "*Public Art Development*" project in the Case Study creates a higher marginal social benefit (a benefit for all parties) than the marginal private benefit.

Optimizing Sustainable Civil Infrastructure Projects

Sustainability is the responsible management of human activity (Welchman, 2012). The mechanism by which civil infrastructure projects are optimally sustainable require management, communication, rules and ethics. The components that comprise sustainable civil infrastructure projects (Context Sensitive Design, Environmental Stewardship and Economic and Financial Management) faced with challenges that are unexpected or uncertain, often leading to a paralysis of indecision. Deliberate management that perturbs the climate of indecision and provide clarity and direction are particularly valuable when future societal, environmental and economic conditions are uncertain. Sustainable civil infrastructure projects demand a shift in project management philosophy from reactions to observed changes to proactive governance (Jiang, Klein, and Margulis, 1998). Therefore, proactive management of projects is a valuable skill for entry-level civil engineers.

A prerequisite for sustainability is a commitment to communication in all forms. Entry-level civil engineers must be able to communicate effectively and persuasively to technical and nontechnical audiences; integrate different forms of effective communication to their audiences; and assess the effectiveness and persuasiveness of their communication. Communication plays a vital role in any sustainable plan or strategy, both internally and externally (Genc, 2017), so much that sustainability communication is evolving as a new interdisciplinary field of research and professional practice (Franz-Balsen and Heinrichs, 2007). I find Pierre McDonagh's definitions of sustainable communication to be quite appropriate for civil infrastructure projects. His definition states, "Sustainable Communication is an interactive social process of unravelling and eradicating ecological alienation that may occur between an organization and its publics or stakeholders" (McDonagh, 1998, p. 599). High levels of complexity and uncertainty are typical characteristics of Issues related to sustainability; thus, communication plays a key role in delivering information across stakeholders (Genc, 2017). The implementation of measures for sustainable civil infrastructure can be difficult, since their management, are not centered, highly dispersed among various actors in the society, and involves multiple levels of decision-making. Therefore, effective communication based on the notion of totality or holism is required. McDonagh (1998) describes the process of sustainable communication as "[embracing] conflict and critique through information disclosure, access to and participation in organizational policies and processes and structures allowing open-ended dialogue" (p. 599).

Social-ecological-economical (sustainability) vulnerability also depends on sensitivity to known risks. Environmental rules of law are central to sustainable development. They provide a supportive legal foundation for sustainability. Environmental rules also integrate environmental needs with the essential elements of the rule of law and provides the basis for improving environmental governance. These rules set standards for environmental quality and limits on pollutants. "Environmental rules […] set conditions for the choice of development location and for the arrangement of functions within a development plan or other local development initiatives." (Salet and De Vries, 2017, p. 189). Rules that constrain development in risky places such as floodplains, watersheds, or wildlife habitats, for example, reduce human vulnerability to environmental disasters.

"While environmental law is a key to achieving sustainability, it is only part of the necessary legal framework. Other needed legal involve a wide range of other laws, including land use and property laws, tax laws, laws involving […] governmental structure, and the like" (Dernbach and Mintz, 2011, p. 532). Rules for sustainable civil infrastructure also include statutes, regulations, policies and procedures that govern construction, real estate and procurement. These rules encompass all aspects of the legal process and the formation of agreements and contracts. They involve matters related to equity, fairness, accessibility, compensation, injury, claims, loss, construction defects, design defects, mechanics' liens, copyright, products liability, construction permits, etc.

The typical structure of a civil infrastructure project contemplates a tripartite system of designers, general contractors, and subcontractors. Their planning, design and construction are complex and challenging. Among other things, they require interpretation of and compliance with many laws, codes, and regulations. For example, entry-level engineers participated in the following steps that were taken to prepare the site for the Heywood Garage project in the Case Study:

(1) A study of the traffic impact and bus route assessment

(2) Environmental assessment and Remediation measures

(3) Land acquisition and tenant relocation

(4) Demolition of existing building

(5) Commercial sign relocation

(6) Geotechnical investigation

Each step required the contacted service of a professional that is verse in the respective task. Once completed the design of the facility began. The design of the facilities requires the contracted services of architects, engineers of various disciplines, and other professionals. When the design is completed, the procurement of a contract for the construction of the facility will take place. To complete the tasks outlined in a contractor agreement, a contractor usually requires subcontractor for goods and services.

Each project is different, and each offers a multitude of varying risks. A purpose of sustainable rules is to provide measures for addressing the risks and liabilities faced by stakeholders in the emerging and changing world of civil infrastructure development. Consequently, entry-level civil engineers must be cognizant of the fundamental knowledge, values, aspirations and interests that are represented in civil infrastructure sustainability rules; how rules can create obstacles to the realization of sustainability infrastructure projects; and how issues of sustainability are handled in the legal order at the project levels.

Engineers, as well as engineering organizations with a climate for sustainability are characterized by a shared sense of moral concern for society, humanity and the environment (Arnaud, 2010). Moral and social values may inspire or inhibit compliance with sustainability and adherence to the general rule of law. Uncertainty is a fact of complex, dynamic civil engineering practice, and ethical issues are persistent in uncertain conditions where multiple stakeholders, interests, and values are in conflict and rules may be unclear. It is therefore reasonable to require that entry-level civil engineers have a sense of professional ethical responsibilities, and ethical reasoning and analysis. Nevertheless, a matter of engineering ethics cannot consist in a set of procedures or values that are applied mechanically to problems.

Ethics means something more than rules and morals. In sustainable civil infrastructure projects, it carries an additional connotation of rightness. It requires the moral engagement between and among civil infrastructure stakeholders. According to Noland and Phillips (2010), “moral engagement is marked by specific conditions of communication which ensure that this communication is uncorrupted by power differences and strategic motivations” (p. 40). I do not wish to distinguish between moral engagement and strategic engagement as other authors have, but to state that if strategic engagement is to be sustainable it must be moral.

Summary of the Chapter

Society is in search for a balance among the interlinkage of economics, society, and the environment. Like the rest of society, civil engineering has called for such a balance. Civil engineering governing bodies look to the humanities and social sciences as ingredients in the formula for balancing economics, society, and the environment in civil engineering education. However, the governing bodies appear to have left the strategy for implementation to educators. Inevitably, if we are to implement humanities and social sciences into the civil engineering curriculum to balance economics, society and the environment, we need to answer the questions: what humanities and social sciences? And to what extent? This study aimed to contribute to these answers. The objective of this study was to identify the modes of humanities and social thought in entry-level civil engineering. The study used a theoretical framework, which combines Vygotsky's concept of the zone of proximal development, the concept of scaffolding and Jean Lave and Etienne Wenger concepts of community of practice and peripheral participation. This combination gave me the framework by which I could investigate the humanities and social sciences in entry-level civil engineering practice and by so doing can inform engineering educators about undergraduate civil engineering curriculum.

The strategy for this study was to first discover a phenomenon from which assertions could be made about humanities and social sciences in entry-level civil engineering. The study began with the collection and analysis of data from job advertisements, a focus group interview and a case study. A summary of the paradigms, which comprise Sustainable Civil Infrastructure Projects, is depicted in figure 4.2. The figure introduces a diagrammatic representation for Sustainable Civil Infrastructure Projects.

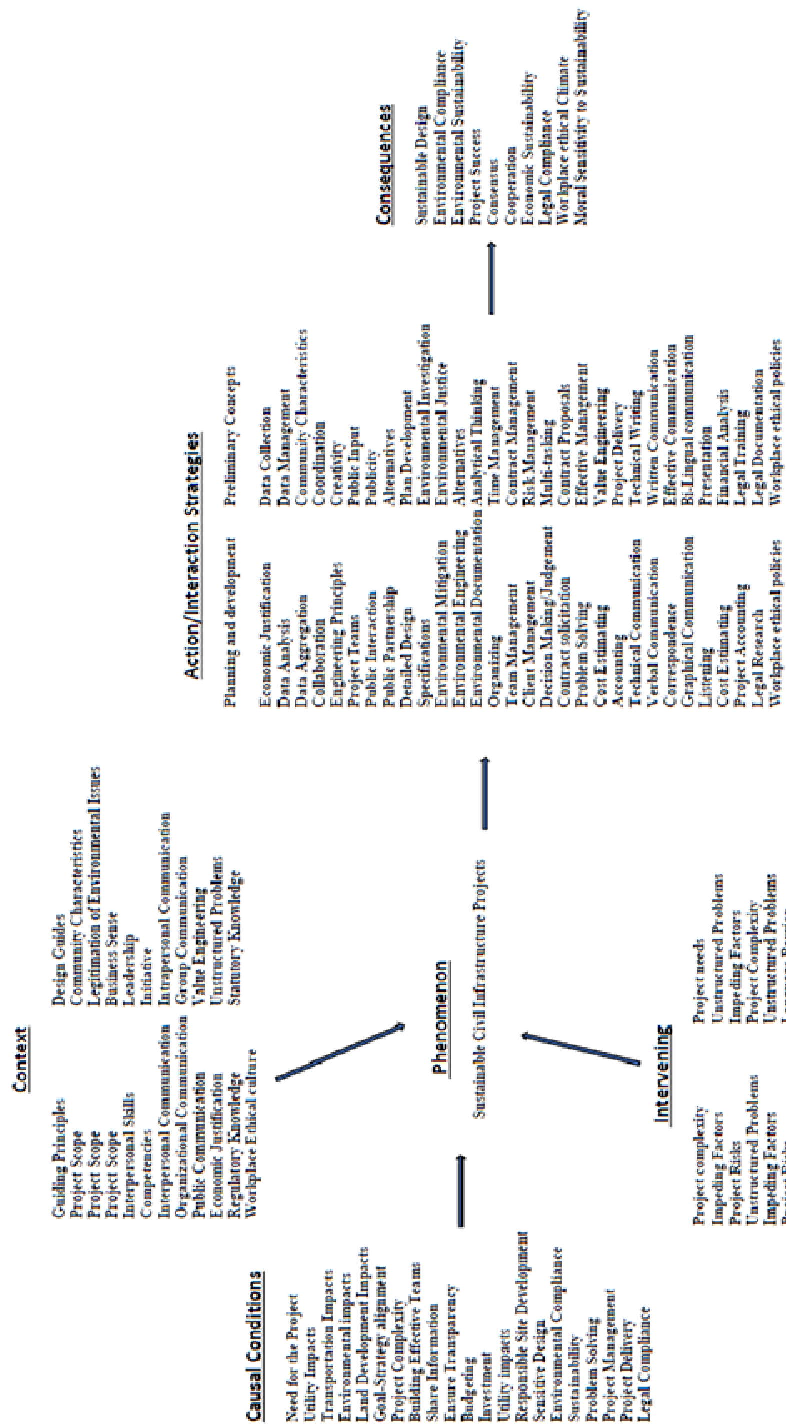

Figure 4.2 Summary of paradigms

The diagram is the expression of this grounded theory of Sustainable Civil Infrastructure Projects and is an organizing device for continued dialogue about the dimensions of sustainable civil infrastructure to demonstrate how concepts can be integrated and set into motion.

In this study, seven concepts emerged from the data: (a) Context Sensitive Design, (b) Environmental Stewardship, (c) Economic and Financial Management, (d) Sustainable Project Management, (e) Effective Communication, (f) Rules for Sustainability, (g) and Ethical Conduct. Through the interaction, interconnections of these seven concepts emerged the phenomenon, 'Sustainable Civil Infrastructure Projects'. The paradigm of sustainability takes into consideration human satisfaction, minimal consumption of matter and energy, and minimal negative environmental impact. However, Sustainable Civil Infrastructure Projects take further steps to optimize sustainability through the conscious application of sustainable management, effective communication, rules and ethics.

CHAPTER V

DISCUSSIONS, IMPLICATIONS AND RECOMMENDATIONS

The purpose of this qualitative grounded theory study was to examine the modes of humanities and social thought in entry-level civil engineering practice, to help better define the broad issues related to non-technical skills necessitating a change in undergraduate civil engineering education. This chapter first expands on the findings that were delineated in chapter four, followed by a summary of major findings. Following the summary, the chapter discusses the findings as they relate to the literature on democratic engineering, social efficiency, humanistic engineering, and holistic engineering. Next, the chapter moves into a discussion on implications of the findings for educators, professional development providers, and others concerned with integrating humanities and social science with civil engineering. The chapter concludes with recommendations for future research.

Expansive Discussions on Findings

I have found that entry-level civil engineers are expected to practice sustainable civil engineering and their work comprises of 'Sustainable Civil Infrastructure Projects'. As I have previously stated, such practice requires conscious application of law, communication, economics and ethics. These discipline branches of social science and humanities are foundational to sustainable civil engineering practice. However, navigating the social characteristics of sustainable civil engineering practice require more nuance. It requires the knowledge and application of social sciences and humanities that are not typically associated with engineering but are blended into sustainable civil engineering practice. The social sciences and humanities are interwoven into sustainable practice but connected in specific ways. The following sections will expand on these connections.

Joni Adamson, a professor of English and Environmental Humanities in the College of Liberal Arts and Sciences and a Senior Sustainability Scholar at the Julie Ann Wrigley Global Institute of Sustainability at the Arizona State University, has developed an impressive repertoire of research on the ways in which sustainability sciences and the humanities work together. Her research on environmental humanities deepens the understanding of social thought and emphasizes the idea that multiple fields must be brought together because our problems with sustainability emerge out of nature and out of human cultures and ways of being. The Society for the Humanities has formed an initiative on sustainability by means of the Humanities and Arts, whereby, scientists and humanists engage in collaborations, working on climate change, energy and other research. The National Endowment for the Humanities states that the humanities entail the study of languages and literatures; linguistics; history; philosophy; religion; ethics; the theory, criticism, and history of the arts; jurisprudence and cultural theory; as well as those aspects of social sciences that have humanistic content and employ humanistic methods (Arizona State University, 2008). Humanities methods include the deep reading of texts and signs, the construction of meaning through interpretation, the exploration of material and visual culture and human practices, and the study of knowledge construction itself (ASU, 2008). The humanities also include the study and application of the humanities to the human environment and to contemporary life, with particular attention to race, class, gender, and sexuality, as well as to diverse peoples and traditions (ASU, 2008). Stegall (2006) quotes David Orr, when explaining the connection between sustainability and humanities, citing:

> "The crisis of sustainability, the fit between humanity and its habitat, is manifest in varying ways and degrees everywhere on earth. It is not only a permanent feature on the political agenda; for all practical purposes, it is the agenda. No other issue of politics, economics, and public policy will remain unaffected by the crisis of resources, population, climate change, species extinction, acid rain, deforestation, ozone depletion, and soil loss. Sustainability is about the terms and conditions of human survival" (p. 56).

In reality, ecological and social environmental problem solving is entangled with social values and conflicts. Regardless of the technical solutions, civil engineers must navigate the complexities of human behavior to activate their utility. This is where social science becomes helpful (Stern, 2018). Putting sustainability concretely into practice requires knowledge about the interactions among society, economy and environment. Sustainability, therefore, demands cross-disciplinary cooperation on different levels among the social science disciplines, as well as between the social and the natural sciences (Becker, Jahn, Stiess and Wehling, 1997). New kinds of problems raised by sustainability and infrastructure projects confront the social sciences with theoretical and conceptual challenges, such as dealing with the natural environment, with gender relations and inequalities, with cultural diversity and multiculturalism, or with technological risks (Becker, Jahn, Stiess and Wehling, 1997). “In the face of the challenge of sustainability, the issue of cooperation and interrelation between social and natural sciences […] has acquired new status as a focus for scientific endeavors and scientific policymaking” (Becker, Jahn, Stiess and Wehling, 1997, p.15).

The subject of sustainable civil infrastructure projects is rich with human and social implications for at the heart of infrastructure projects is the transformation of nature for the convenience of human use. Schulz (2012) outlines the human-nature relations in the following contexts:

> “At the heart of the discourse on human-nature relations is the recurring theme about a relationship with nature. Philosophers talk about this in terms of ethics, or morality. Sociologists talk about culture, values, and the ways in which societies interact with nature. Conservationists talk about land ethics, and the experiences that result from encounters with nature. But at the core is the individual, and his or her understanding of his place in nature.” (p.66)

What Modes of Humanities and Social Thought inform Sustainable Civil Infrastructure Projects?

As concepts, the environment and infrastructure projects together presuppose an interest in the management of natural resources. Anthropology adds to this a concern with the ways in which peoples bring their cultural imaginations to bear on the utility of such resources. At a fundamental level, the civil engineer's environmental psychology, the extent to which civil engineers believe that they are connected to, or separate from, nature is an essential part of sustainable civil engineering practice.

Sociology

> "No single concept is mentioned by more articles published in Environmental Sociology than the concept of sustainability. This is not surprising. No other concept has done more to shape contemporary understanding of the social, economic and ecological interdependencies implicated in environmental change." (Lockie, 2016, p.1)

Sociology has a unique role in the social sciences in its emphasis on social behavior and human groups. This study found that the execution strategies for a Sustainable Civil Infrastructure Project is shaped by community norms. Community norms are the set of behaviors expected in a community, based on the community's values, traditions, policies, etc. For example, in the "*Better Bus Stop"* project, discussed in the body of this study, it was discovered that queuing is not a traditional norm in some communities. Therefore, activities at the bus stops in these communities such as boarding, and ticket purchasing did not include queuing. That fact had to be considered in the design of the bus platform. Other communities, as was found in the "*METRO Orange Line"* project, attempt to preserve their traditional way of life promoting collective culture. As a result, in these communities, there is a lower provision for physical infrastructure impacts.

In these communities, effective communication is critical for consensus and cooperation.

The study of sociology provides entry-level civil engineers with the knowledge in social inequality, social institutions, population and the environment, and societal change. These are essential components of Sustainability Civil Infrastructure Projects. The conflicts over how sustainability should be interpreted and implemented in specific settings such as sustainable civil infrastructure projects, provide opportunities for the social sciences that are fundamentally questions about knowledge, values, aspirations and interests that are represented in sustainability plans and rules. According to Lockie (2016), these “are questions that demand sociological input” (p. 2). Moreover, they are questions civil engineers can address standing on safe sociological ground, using familiar theories and methods. This study found that doing so require entry-level civil engineers to understand the characteristics of the communities affected by their initiatives. Entry-level civil engineers must be aware of the importance of human societies and cultures and their development and the context of cultural relativism and how it plays out in the field of civil engineering practice.

Psychology

A finding of this research is that Sustainable Civil Infrastructure Project require a multidisciplinary approach to planning and design that incorporates the viewpoints of the various stakeholders. Psychology is beneficial to entry-level civil engineers to help them better understand what people expect and how people interact with infrastructure products and technologies, to make them safer, more effective and more reliable and to optimize the performance, productivity, usability and safety of civil engineering systems.

Projects such as the "*Metro Transit Police Department"* and "*Better Bus Stops"* have shown that facilities are not just mechanistical, inanimate buildings and technology. Factors such as personal space, function of space and meaning of place, form the relationship between these facilities and the people who use them. Without these factors, civil infrastructure misses their essential human nature. Civil infrastructures are primarily a lived emotional experience and understanding human behavior and habits play a role in sense-making for the spaces and places that civil infrastructure create. Projects such as the "*METRO Orange Line",* demonstrated increasing social effects of civil infrastructure on the elderly, the disabled, homeless people and various social groups. The following is a mail-in comment by a concerned "*METRO Orange Line"* project stakeholder:

> *"QUESTION: I just highly doubt pedestrians, even with children in strollers and grocery carts and stuff with the elderly when they're pushing their groceries, aren't going to be able to cross that north to south easily."*

The projects in the Case Study showed that basic psychological needs have to be met before progress on negotiations and disputed resolutions could be made. Crucial to stakeholder were feeling secure; belonging; cultural identity; an ability to participate; and a sense of fairness. Place attachment theory from environmental psychology demonstrate how and where we live has profound emotional and physical impacts, influencing our sense of self, belonging and purpose. Functional and emotional attachments are two types of place attachment that are identified. Functional attachments indicate the opportunities for fulfilling of specific goals or activity needs. Emotional attachment refers to as place-identity, concern the importance a person attaches to the place because of what the setting symbolizes. The following example is from the "*METRO Orange Line"* public comments. It highlights a citizen's desire/expectation for the project:

> *"As a person who uses all the modes of transportation impacted by the project, I think the plan is very functional. But I hope the bike, pedestrian and Lake street level aspects will be as visually appealing and unique as the iconic transit center design. I highly encourage green space where possible public art along walls and even under the bridges. Perhaps a light design accompanying ambient music – something you might have seen at an airport – to connect the north and south transit centers."*

According to the findings of this research, Sustainable Civil Infrastructure Projects has the potential to influence the enviro-effectiveness of our civil infrastructure positively. "The notion of being connected with nature is a psychological one […] the extent to which an individual believes that s/he is connected to nature has cognitive, affective, and behavioral components" (Schultz, 2012, p.62). The psychology of Sustainable Civil Infrastructure Projects sees sustainability in terms of improving the quality of life of every human being (Di Fabio, 2016a, 2017). In Accordance with this point of view:

> "[…] the construction and managing of a sustainable project is based not only on using increasingly smaller amounts of resources but also on regenerating resources (Di Fabio, 2016a). A sustainable project is thus

accessible, de-constructible, and recoverable and comprises oxygenating processes aimed at promoting individual and organizational well-being (Di Fabio, 2016a; Di Fabio and Maree, 2016). A sustainable project proposes what does not yet exist; it changes what exists according to new goals to achieve new results; and it transfers knowledge and solutions to meet new challenges" (Di Fabio, 2017, p. 140).

Di Fabio (2017) argues that the sustainability of a project from a psychological point of view involves vertical and horizontal axes of reflexivity. The vertical axis involves awareness of our place in time. It sets out a vision of how our historic environment can be understood, valued, cared for and enjoyed. The horizontal axis, conversely, is concerned with the promotion of mutual gain, namely gain for others and gain for the self on the one hand, and connectedness focused on reflexivity on the other hand (Di Fabio, 2017). Using Di Fabio, (2017) definition of a sustainable project, Sustainable Civil Infrastructure Projects are accomplished by a macro-level approach to the relationship between people and society.

Philosophy

Based on this research finding, in Sustainable Civil Infrastructure Projects, stakeholders play an important role in identifying issues and associated solutions that may better meet and balance the needs of the community. Therefore, entry-level civil engineers have to consider whose knowledge they rely upon and what is the basis for making claims about sustainability. Philosophy is a useful tool when considering the rational justification, logical inferences, human values, criteria for establishing the claims of knowledge and certainty, and interpretations of the nature of reality of civil infrastructure projects.

The field of design is a major focal point for Sustainable Civil Infrastructure projects. Design is, at its core, “an art of thought and communication that can induce in others a wide range of beliefs about practical life for the individual and for groups.” (Stegall, 2006, p. 3). The role of the entry-level civil engineer as designer in Sustainable Civil Infrastructure Projects is to envision products, processes, and services that encourage widespread sustainable behavior. Stegall (2006) calls this design philosophy, “Intentional design”. Intentional design is a conscious recognition that the artifacts created by Sustainable Civil Infrastructure Projects reflect community values and encourages positive, constructive ways of life.

The following exert from the write-in comments for the “*METRO Orange Line”* project, is an example of the philosophical arguments with which entry-level engineers are expected to grapple. The stakeholder argues that a translucent wall that was used as a sound barrier along Minnehaha Parkway can be used to protect a historical fence from salt spray and also allow the historical buildings to visible to the community.

> *“QUESTION: Can I just ask one question. I was at some of the meetings of the PAC, and one of the comments I heard, especially along the historic Healy block, is some of the salt spray damaging wrought iron fences and that kind of thing. And I know, maybe you don’t want a sound wall there, but look at what 35W did next to Minnehaha Parkway and there’s that*

> *glass wall. It's shorter than a noise wall, and I'm not speaking for that neighborhood at all, but just, I was just thinking, you know, hey, if you have salt spray, is there any way to put something that's transparent that wouldn't necessarily be a noise wall, but would protect those properties from some of that salt spray, but also be able to give you that nice look into those historic properties and into the Midtown Neighborhood."*

The argument is as follows:

> In mixed development areas, translucent walls are used to protect residential building from noise and to allow businesses to be visible to the public. Since translucent walls act as barrier and allow visibility, they can also be used to protect historical buildings from salt while allowing them to be visible to the public.

However, the entry-level engineer also has to determine if a translucent wall conforms to the preservation goals of the historical properties.

Anthropology

The previously referenced interviews conducted for the "*METRO Orange Line"* project is an example of an anthropological observation. The engineers carried out interviews to understand more deeply the meanings that individual people place on their day to day activities, with a consequent interpretation of the collected data. The engineer is interested in the initiative of the "METRO Orange Line" project that is going to make a direct intervention in the community, therefore, needed information about the community and its inhabitants. It is important for the engineer to observe how this proposed change would affect the context in which it will be carried out.

A finding of this research is that entry-level civil engineers must understand the holism of a Sustainable Civil Infrastructure Project; must contemplate the interaction between a given project and the social, environmental, and the economic dimensions of the system enclosing it; and value the input of all stakeholders that are affected by a project. Anthropology adds a concern with the ways in which peoples bring their cultural imaginations to bear on the utility of resources. The field of environmental anthropology draws upon various domains within anthropology and across disciplines from the humanities to the social and natural sciences (Kopnina and Shoreman-Ouimet, 2011). Kopnina and Shoreman-Ouimet (2011) argue that anthropology affords valuable insight into our relationship with the environment, which assist project designers, and peoples impacted by today's environmental problems. This is helpful to entry-level civil engineers in designing holistic infrastructure systems.

Veteto and Lockyer (2008) suggest that "an anthropological engagement with permaculture represents an especially timely opportunity for anthropologists to move toward sustainability in ways that complement and enable us to extend our traditional areas of theoretical and practical expertise" (P. 47). "Permaculture is a holistic system of design, based on direct observation of nature, learning from traditional knowledge and the findings of modern science" (Veteto and Lockyer, 2008, p. 48). It is a set of design principles centered on whole systems thinking simulating or directly utilizing the patterns and resilient features observed in natural ecosystems. Permaculture is based on the belief that the focus on holism and interconnections is the best way to create systems that function in a sustainable manner.

History

As anthropological observations look for meaning and the consequences of civil infrastructure, civil engineers could also benefit from historiographical research work. History provide a context to the rituals and daily behaviors observed. Contextual condition is one of the sub-categories in the paradigm that makes up 'Sustainable Civil Infrastructure Projects'. Beyond the historical events and uses that shape the present site conditions of a proposed development as described in the "*Heywood Garage"* project, history also puts into contexts, the characteristics of a community. For example, the *Better Bus Stop* project included as one of its essential questions, asked, "are there buildings, structures, areas within your neighborhood that are historically important to the community? If so, what are they?" The idea behind such as question is that every community has a history that created its current structures, norms, attitudes, and policies, and any intervention in within that community must appreciate this history and understand why the current system exists in the form that it does. Place meaning and attachment can play a pivotal role in civil infrastructure planning processes. In Sustainable Civil Infrastructure projects, residents' identification and articulation of place meanings marks the beginning of the design process. The engineer's responsiveness to place attachments and place meaning help to make the infrastructure project a success because residents had an active role in the process, and because they were able to ensure that the places that are especially important and meaningful were preserved in the new plan.

According to the research findings, stakeholder involvement is a salient part of Sustainable Civil Infrastructure Projects. However, each person and community bring with them an array of beliefs and cultural norms. Therefore, entry-level civil engineers must be thoughtful about historical cause and effect in complex social contexts; must be thoughtful about trends and patterns in social evolution; and the role of human values, beliefs, fears, and cultural inclinations in civil infrastructure projects. According to The American Society for Environmental History (ASEH), environmental history "aspires to advance a greater understanding of the history of human interaction with the rest of the natural world (ASEH, 2006). Environmental history foster dialogue between humanistic scholarship, environmental science, and other disciplines, and to support global environmental history efforts that benefit the public as well as the general scholarly community (ASU, 2008). Environmental history can contribute to Sustainable Civil Infrastructure Projects in the following ways:

> (1) Analysis of "path-dependence," or historical momentum; (2) methodological and intellectual skills in tracing change over time, identifying trends and patterns in social and institutional evolution; (3) skills in identifying historical cause and effect in complex social contexts; (4) access to a rich collection of case studies from the past for comparison with contemporary events and conditions; (5) willingness and ability to

assess the role of human values, beliefs, fears, and cultural inclinations in shaping human behavior. (ASU, 2008, p.6)

Veteto and Lockyer (2008) in their article, *Environmental Anthropology Engaging Permaculture: Moving Theory and Practice Toward Sustainability*, agrees with Balee´ (2006) and underscores the usefulness of historical ecology:

> “The merging of historical ecology with permaculture can provide practitioners with long-term data on how human–environment interactions have taken place in specific places. […] Both permaculture and historical ecology have a shared interest in the applied realm, as applied historical ecologists are cognizant of their role in supplying baseline data related to time depth and traditional knowledge that can be used to restore past landscapes” (p. 54)

Literature

This research found that effective communication is an important part of Sustainable Civil Infrastructure Projects. As such, entry-level civil engineers must be proficient in the use of literature, to initiate and engage in effective dialogue with non-technical audiences regarding socio-humanistic critiques of engineering processes and products. This is especially important as Sustainable Civil Infrastructure Projects require cooperation among stakeholders of varying backgrounds. Environmental writers and literary critics illustrate the ways in which people with different cultural, racial and gendered backgrounds often have different ideas about what constitutes "nature's balance" or what constitutes abundance versus scarcity (ASU, 2008). At the sustainable level, civil infrastructure projects are best served by engineers who are abreast of the discourse on ecological, social and economic issues. For example, in the Better Bus Stop project and in most civil infrastructure projects today, the effect of civil infrastructure projects on historic sites is a concern that must be addressed. Doing so requires civil engineers to identify such sites within their projects through a survey. Literature, fiction or non-fiction, is a useful start for determining areas of previous terrain disturbance to guide field surveys, provide historic context background to help evaluate site significance, provide background information. Literature searches were performed prior to undertaking fieldwork for the *Better Bus Stop* project. Literature searches were used to assess the need for field survey and to determine known sites within a project area. Books such as, *Lost Minnesota: Stories of Vanished Places* and *Minnesota Mysteries: A History of Unexplained Wonders, Eccentric Characters, Preposterous Claims & Baffling Occurrences in the Land of 10,000 Lakes* provide history and context that are useful in surveys in Minnesota, such as the one performed for the *Better Bus Stop* project.

The Arizona State University, Institute for Humanities Research provides a comprehensive summary of environmental literature, its progression and significance to sustainability. In its article, *General principles – Humanities and Sustainability*, the institute summarizes the importance of literature on the environment to sustainability. The article discusses the evolution on environmental literature, starting from early environmental critics who tended to equate the “environment” with “natural environment”. According to the article, writers such as Emerson, Thoreau, Muir and Tempest Williams took urban and degraded landscapes just as seriously as “natural” landscapes. They expanded the literature to accommodate the claims of the Environmental Justice Movement. Books such as, *Minnesota’s Natural Heritage: An Ecological Perspective*, Illustrated with hundreds of maps and color photographs that reveal the changing character of Minnesota, traces the development of the state's natural environment, how the land formations, plants, and animals became a part of its fabric, and how they have changed over time. Such books provide historical contexts for engineers planning infrastructure projects in Minnesota and certainly for projects managed by entry-level engineers in the Case Study.

The field continues to expand its parameter of to include global literatures and writers such as Derek Walcott, Ken Saro-Wiwa, Michiko Isimure, and Mahasweta Devi who are writing about diverse cultures and the linked social and environmental challenges they face. More recently, the influence of the Environmental Justice movement has moved beyond the “social” vs. “deep ecology” debates of the 1980s and 1990s (ASU, 2008) toward substantial engagement with issues of environmental welfare and equity of more pressing concern to the impoverished and socially marginalized. *The Days of Rondo, by Evelyn Fairbanks* and *Oral History Interviews of the Rondo Oral History Project, 1997-1998, 2003-2004* provide entry-level engineers in the Case Study with historical perspective on environmental justice issues.

Human Geography

This research found that because of the three interactions that comprise concerns of Sustainable Civil Infrastructure Projects – socio-environmental and socio-efficiency and enviro-efficiency – entry-level civil engineers must be aware of how civil infrastructure projects are affected by the spatial aspects of population growth and distribution, cultural differentiation, urban growth and decline, regional development, and the location of economic activity, as well as problems associated with these processes. These are human geography concerns. For example, according to the project documents, "*As a part of the METRO system, the Orange Line will connect people across the region to job centers, housing options, transit stations, and key destinations in the I-35W corridor. The Orange Line will improve access to 162,000 jobs and 64,000 residents, including 30,000 jobs and 40,000 residents outside of downtown Minneapolis."* Human geography has useful applications for Sustainable Civil Infrastructure Projects as it concentrates on social, economic, political, cultural and human-environment processes and patterns and how they change over space and time. "Geographers deliver historically richer accounts of the ways that power loci latch on to ideas of 'nature', and hence 'sustainability', and influence social struggles and debates over the environment" (Sneddon, 2000, p.536).

Arts

This research found that public art is a vital part of Sustainable Civil Infrastructure Projects. Therefore, entry-level civil engineering must understand the importance of art to community identity and how that connection relates to civil infrastructure projects. Cemented in the Global landscape is a vast history that can be found in rock art created by indigenous people. Archaeological evidence suggests that rock art may be thousands of years old. Other traditions such as body painting, bark painting and sculpture developed by indigenous people gives meaning to the landscape.

Civil engineers are to create their designs with regard to the larger societal context in which their work exists. Like the indigenous people, sustainable civil infrastructure projects require that their creations must give meaning to the local landscape. This can be accomplished through the arts. For example, Lexington Avenue and University Avenue in the City of St. Paul was the home of Lexington Ballpark, home of the St. Paul Saints baseball team from 1897 - 1956. The light poles at the entrances to the Lexington Parkway Light Rail Station platforms mimic the construction of the beams of the old ballpark and a low-relief panel depicting Roy Campanella's (St. Paul Saints, 1948) hands holding a baseball bat can be found on the sides of the utility cabinets as shown in figure 5.1.

Figure 5.1. Roy Campanella holding a baseball bat

The arts are one of the last fields to be engaged in social responsibility and ecological awareness (Meade, 2008). The arts can be considered to be inherently collaborative. Artists are set within networks of production that require a whole set of materials and other actors to bring a work of art into being (Connelly, Guy, Wainwright, Weileder and Wilde, 2016). By understanding the arts as a component of a healthy cultural ecosystem, civil engineers can begin to see how environmental practices contribute to a thriving whole.

Summary of Discussion

Beyond its economic and environmental integrant parts, the reality of Sustainable Civil Infrastructure Projects is entangled with social values and conflicts. I found that in addition to law, communication, economics and ethics, the humanities and social sciences of sociology, psychology, philosophy, anthropology, history, literature, human geography and art, were also salient to entry-level civil engineers' practice. Resultantly, these humanities and social sciences influence civil engineers' thoughts in specific ways. To summarize the arguments and assertions made in this study concerning the modes of humanities and social thought that are salient to entry-level civil engineers, I offer the following statements:

(1) Entry-level civil engineers' work comprises of Sustainable Civil Infrastructure Projects.

(2) Entry-level civil engineering must understand the importance of art to community identity and how that connection relates to civil infrastructure projects.

(3) Entry-level civil engineers must be thoughtful about historical cause and effect in complex social contexts; must be thoughtful about trends and patterns in social evolution; and the role of human values, beliefs, fears, and cultural inclinations in civil infrastructure projects.

(4) Philosophy is a useful tool when considering the rational justification, logical inferences, human values, criteria for establishing the claims of knowledge and certainty, and interpretations of the nature of reality of civil infrastructure projects.

(5) Entry-level civil engineers must be proficient in the use of literature, to initiate and engage in effective dialogue with non-technical audiences regarding socio-humanistic critiques of engineering processes and products.

(6) Psychology is beneficial to entry-level civil engineers to help them better understand what people expect and how people interact with infrastructure products and technologies, to make them safer, more effective and more reliable and to optimize the performance, productivity, usability and safety of civil engineering systems.

(7) The entry-level civil engineering must be cognizant of the fundamental knowledge, values, aspirations and interests that are represented in civil infrastructure sustainability rules; how rules can create obstacles to the

realization of sustainability infrastructure projects; and how issues of sustainability are dealt with in the legal order at the project levels.

(8) Entry-level civil engineers must be aware of the importance of human societies and cultures and their development and the context of cultural relativism and how it plays out in the field of civil engineering practice.

(9) Entry-level civil engineers must be aware of how civil infrastructure projects are affected by the spatial aspects of population growth and distribution, cultural differentiation, urban growth and decline, the spread of ideas and innovations, regional development, and the location of economic activity, as well as problems associated with these processes.

(10) Entry-level civil engineers must have a sense of professional ethical responsibilities, and ethical reasoning and analysis.

(11) Proactive management of projects is a valuable skill for entry-level civil engineers.

(12) Entry-level civil engineers must be able to communicate effectively and persuasively to technical and nontechnical audiences; integrate different forms of effective communication to their audiences; and assess the effectiveness and persuasiveness of their communication.

(13) Entry-level civil engineers must know how to analyze projects' costs and funding options, economic return on investment and risk; and knowledgeable about concepts of finance and economics within a civil engineering project.

(14) Entry-level civil engineers must understand the holism of a civil infrastructure project; must contemplate the interaction between a given project and the social, environmental, and the economic dimensions of the system enclosing it; and value the input of all stakeholders that are affected by a project.

Context of Findings

As discussed in the literature review, there are multiple ways of approaching the subject of civil infrastructure sustainability. Therefore, a parallel discussion of the study's key finding and the literature review, may unravel this tangle of perspectives by serving as a point of reflection. One could postulate that there are undeniable qualities and concerns with respect to sustainability when put through the lens of civil infrastructure projects.

Sustainable Civil Infrastructure and Democracy

Van Poeck, Goeminne and Vandenabeele (2014) point to the paradox we face between democratic education and sustainable civil infrastructure by referencing to Wals (2010a) stated:

> "…we face here a paradox between, on the one hand, the sense of urgency emerging from a deep concern about the far-reaching implications of many sustainability issues and the injustices they often bring about and, on the other hand, restraints – based on pluralistic values – against education as an instrument to foster predetermined ways of

> thinking and acting. This paradox brings about an ambiguous relation between democracy and sustainable development…" (p. 2)

According to (Huckle, 1999) "the political debate surrounding sustainability is part of a larger debate focusing on what mode of regulation will allow capitalism to survive in a viable form" (p. 36). However, Kweit and Kweit (1986) suggest that:

> "policy analysis tends to concentrate power in the hands of a few experts and that policy analysis is most compatible with bureaucratic decision-making which is antithetical to citizen participation. Because the policy analysis process relies on specialized techniques, expertise is an inherent component of policy analysis. As such, the role of citizen participation in the traditional policy analysis process is minimized." (p. 22)

Barber (2014) shows equal concern about the relationship between sustainability policy and the democratic process though for a different justification:

> "In the real world of corrupted, minimalist government dominated by money and special interests in which we currently dwell, democracy is hardly at its best. Under the sway of market fundamentalism, we actually instruct citizens to eschew deliberation: to think of their task as expressing impulsive private preferences, encouraging them to regard the public good as little more than an aggregation of those preferences. We allow them to confound opinion and knowledge to the detriment of judgment. Sometimes we even seem to think that by denying expert science we honor "democratic" thinking – as if shared ignorance and democracy are the same thing." (p. 11)

In his influential work however, Democracy and Education, Dewey (1916) clarifies the relationship between democracy and education by pointing to communication as the carrying connection between the two. The view that Dewey took was on the one hand that “democracy was not primarily a mode of management and control, but more an expression of a society imprinted by mutual communication, and consequently, a pluralist life-form” (Englund, 2006, p. 508). Dewey suggest a “broad, social definition of democracy, in which democracy is not merely seen as a mode of government but is understood as a “mode of associated living” characterized by inclusive ways of social and political action” (Biesta, 2007, P. 2). This philosophy of informed consent that Dewey assigns to Democracy is in keeping with Sustainable civil infrastructure. He sees the democratic person as the person who both shapes and is shaped by the democratic form of life. The individual who possesses social intelligence and participates in social interaction and cooperative problem-solving. These definitions of democracy and the democratic individual implies a democratic education that instils in the individual a sense of responsibility in the democratic process. Such an individual is who is most becoming to sustainable civil infrastructure.

Sustainable Civil Infrastructure and Social Efficiency

In sustainable civil infrastructure, social efficiency takes on a new meaning that goes beyond that which David Snedden described. Snedden differentiates between the purposes of liberal education and vocational education in his assessment that:

> "…. the most useful definition of liberal education now available is that which defines it primarily in terms of education toward higher utilization. Man stands, to the world about him, in a twofold relationship. He is a producer of utilities on the one hand, and on the other, for his own growth and development, he must utilize utilities. That education which trains him to be a producer is vocational education. That education which trains him to be a good utilizer, in the social sense of that term, is liberal education." (Snedden, 1914, p. 157)

Snedden went on to say:

> "The vocational school should divest itself as completely as possible of the academic atmosphere and should reproduce as fully as possible the atmosphere of economic endeavor in the field for which it trains." In addition, "the pedagogical methods to be employed must be those involving concentration, painstaking application to detail, and continuity of purpose," and these need to be precisely tailored to the skill demands of each occupational specialty" (Snedden, 1914, p. 160).

This separation of production from utility is contrary to sustainable civil infrastructure. Snedden definition of social efficiency take a myopic view of economic development and devoid it of its responsibilities to the social and ecological environment. Sustainable civil infrastructure on the other hand sees social efficiency as the marriage between economic development and social responsibility. It is the optimal distribution of resources in society, considering all external costs and benefits as well as the internal costs and benefits. Social efficiency as an educational purpose should mean cultivation of power to join freely and fully in shared or common activities; in occupations having a social meaning, social efficiency incorporates the positive use of native individual capacities (Dewey, 1916). And its measure of humanities and social science are in utilization to secure efficiency.

Sustainable Civil Infrastructure and Holistic Engineering

Chapter 2 describes holistic engineering as a different and better way of doing engineering. (Grasso and Martinelli, 2007; Mahmoudi, Jafari, Nasrabadi and Liaghatdar, 2012) suggested that better serve humanity the civil engineers must understand the human condition in all its complexity, which requires the study of literature, history, philosophy, psychology, religion, and economics, among other fields. The term Grasso and Martinelli (2007) assigned to this engineering philosophy is "unity of Knowledge". The discourse on holistic engineering from the literature review is in lockstep with the findings of this study. Restating the findings to the research question - what Modes of Humanities and Social Thought inform Sustainable Civil Infrastructure Projects? - in addition to law, communication, economics and ethics, the humanities and social sciences of sociology, psychology, philosophy, anthropology, history, literature, human geography and art, were also salient for entry-level civil engineers' practice.

Implications for Higher Education and Training

Is the impetus behind civil engineering education to make students omni-competent or is it to make them better workers? This is an important question to answer in our assessment of civil engineering education. In proposing a framework for approaching undergraduate civil engineering education, the challenge is how to make the curriculum universal and useful; simple yet sufficient. This research found that entry-level civil engineers are required to practice sustainable civil engineering. The findings suggest that the undergraduate civil engineering curriculum must include, law, communication, economics, ethics, sociology, psychology, philosophy, anthropology, history, literature, human geography and art. That is a challenge that require collaboration between engineering educators and non-engineering educators. Most engineering professors have no formal education in humanities and social science. Therefore, educators and professionals with backgrounds in the humanities and social science fields can help enormously in making engineering education more sustainable. Collaboration can introduce the next generation of engineering educators to a wide variety of approaches to civil engineering curriculum and pedagogy. This will require integration, that is connecting the concepts of humanities and social science into civil engineering education.

Sustainable civil engineering requires a more philosophical thinking approach than traditional civil engineering. Sustainable civil engineering requires educators and practitioners to wonder and to philosophize about future events; and to be creative and integrative in their solutions to issues that are complex and of large scale and scope. Though sustainable civil engineering demand abstract thought, we must not be deterred from the practical nature of engineering in general. Achieving the objective of a broader engineering education focus will require a comprehensive analysis of education theories as they pertain to the technical aspects of engineering. So, as to not repeat the errors of the past, we must also embrace the technical aspect of engineering. In conclusion, civil infrastructure systems are a global phenomenon and as such, approaches to edification on the subject matter are rich in diverse viewpoints. Therefore, an objective of civil engineering educators ought to be committed members of the global community that is dedicated to enhancing this specialized area of education. An immediate goal is to become more cognizant and abreast of engineering education theory and of education theories and policies in general.

Implications for Civil Engineering Practice

This research discovered a wide range of environmental stewardship practices and policies involving energy efficiency, water conservation, climate change, renewable portfolio standards, and other issues. This has expanded the boundary of entry-level civil engineering practice.

Civil engineers and future civil engineers play a vital role in the sustainable development in meeting the needs of the public (Rodgers, 2009). As the stewards of society's physical infrastructure, civil engineers must lead in sustainable planning, design and construction. That means entry-level civil engineers must embrace the ethic of sustainability in engineering education and in practice. It has been argued in this study that Sustainable Civil Infrastructure Projects is now absolutely central to the practice of entry-level civil engineers and this needs to be reflected in the education and training of civil engineers.

As the undergraduate degree is the first professional degree for civil engineering, sustainable civil engineering will require more on-the-job training. In order for entry-level engineers to assume a greater leadership role, training will need to prepare them to communicate the importance, functions and impacts of civil infrastructure in daily life, and in sustainability terms.

Implication for Human Resource Development

Engineering practice continues to evolve as a result of new technology and a dynamic global environment. Together with changes in the global context, civil engineering organizations are changing their approach to global mobility and cross-border transfers. With increasing globalization and international competitiveness, many civil engineering firms have realized the importance of well-trained and competent professional staff in their quest for competitive advantage. Sustainable civil engineering practice provides a career path for civil engineers in this dynamic global environment.

This study's conceptual framework provides educators and organizations with a model for determining civil engineering human resource development. An accurate understanding of engineers' career paths and the skills and knowledge required at each stage could enable engineering educators to better prepare future engineers. Based on the model, engineering programs should look at the knowledge density of the next stage along an engineers' career paths to prepare them for greater responsibility. There is a clear need for more effective integration between education and practice, however, understanding engineering practice needs improvements because there is an inadequate body of work on engineering practice. There appear to be a misalignment between civil engineering education and civil engineering practice. At the undergraduate level, engineering education focuses on the physical sciences; on design; and on making students technical experts. However, engineering practice also demands skills in the humanity and social science subjects.

Recommendations for Future Research

The research undertaken for this dissertation has highlighted a number of topics on which further research would be beneficial.

Recommendation for Research on Integrated Civil Engineering Education

Pedagogical and curriculum integration provides the theoretical framework for engineering education integration. An integrated curriculum would connect different areas of humanities and social sciences to civil engineering by cutting across subject-matter lines and emphasizing unifying concepts. Whiles pedagogical integration would use teaching, learning and technological strategies, including individual, group and class work.

The integration of Integrative learning and curriculum integration reflect the progressive tradition of John Dewey, in which subject matter is connected to real-life and made more meaningful to students (Beane, 1997). Advocates of more integrated approaches to engineering education argue that teaching engineering in a more connected manner, especially in the context of real-world issues, can make engineering subjects more relevant to students and teachers. This in turn can enhance motivation for learning and improve student interest, achievement, and persistence.

Despite the rise in interest in providing students with learning experiences that foster connection made across disciplines, there is little research on how best to do so or on what factors make integration more likely to increase student learning, interest, retention, achievement, or other valued outcomes. To further investigate integrated engineering education, researchers need to document in more detail their interventions, curriculum, and programs implemented, especially how subjects are integrated and supported. More evidence needs to be collected on the nature of integration, scaffolding used, and instructional designs applied (Abell and Lederman 2007; Wang et al. 2011). Clear outcomes need to be identified and measured.

Merely writing engineering standards into curriculum will not necessarily improve or increase how it is being taught. Since engineering primarily focuses on problem solving and student-learning outcomes, the standards need to be integrated across all content areas at all levels.

Recommendation for Qualitative Research Method

Engineering research has relied on rigorous quantitative methods. However, this study has shown that qualitative research can provide insight into the answers to 21st century civil engineering questions. The qualitative research methods used widely in the social sciences have not planted firm roots into the engineering education literature. One reason for this reluctance is that engineering educators feel more comfortable with quantitative research methods because they result in numerical data, a concept with which most engineers are familiar. However, rather than the investigator's level of comfort, the purpose of the investigation should primarily guide the decision to use qualitative, quantitative, or mixed methods (Leydens, Moskal and Pavelich, 2004). Another is that the only way to prove anything in education is to run many studies on large populations that point to the same broad result. This is not the kind of reasoning engineering professors are accustomed to employing in their research, and most of them are skeptical of it (Wankat, Felder, Smith and Oreovicz, 2002). Also, (Berliner, 2002) argues that qualitative research is often considered soft, unreliable and imprecise when compared with other sciences such as bridge design and electronic circuit design. However, engineers have much to learn from the qualitative research methods used by our colleagues in the humanities who have been using such methods for many years (Petroski, 2009). And yet another cited reason for a disproportional number of quantitative researches in engineering education is that few engineering professors are familiar with the complexities and ethical issues involved in human subject research (Wankat, Felder, Smith, and Oreovicz, 2002). A second challenge facing engineering education is the impact of the scholarship of teaching and learning on mainstream engineering education (Wankat, Felder, Smith, and Oreovicz, 2002). Most engineering professors are not verse in student-centered instructional methods. While individual engineering professors have always explored innovative teaching techniques, few instructional approaches developed entirely in engineering have achieved widespread acceptance (Wankat, Felder, Smith, and Oreovicz, 2002).

Activities that characterize the formal study of teaching and learning in engineering are typically the same as those usually associated with disciplinary scholarship in the field such as, seeking and securing grant support for research, presenting research results at professional conferences, and publishing them in refereed journals (Wankat, Felder, Smith and Oreovicz, 2002). However, certain differences between engineering research and educational research pose significant challenges to engineering faculty intending to engage in the latter (Wankat, Felder, Smith and Oreovicz, 2002).

Conclusions

Sustainable Civil Infrastructure Projects can only be achieved through the integration of policies and practices that connect or integrate the environment, the economy and the society. This study proposed a construct outlining the humanistic side of civil engineering that I assert can integrate humanities and social science into civil engineering curriculum. This study, I believe, provides sufficient evidence to make some claims as to what humanities and social science knowledge and skills should be incorporated into civil engineering education and urge others to consider systematically investigating how the inclusion of and focus on the humanistic side of engineering influences engineering learners. I also urge engineering educators and researchers to continue to push on the inclusion of the humanistic side of engineering as a critical aspect of learning engineering and forge new paths for research along these lines.

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Appendix A1

JOB DESCRIPTION OPEN CODING

Incidents	Sub-Category
Experience in final design	Detailed Design
land development design	
Technical skills in design preparation using design tools	
Assist a Senior Engineer with site designs	
Understand all aspects of design.	
design federal, state, county and city/state aid roadway design and municipal projects	
As a member of our team, you will work alongside Engineers, Designers, and Technicians to provide engineering expertise for various linear and site design railroad projects.	
Performs design that does not require previous experience	
Seeking a civil engineer or civil designer to join our solar design team for the design and coordination of our solar energy projects.	
Detailed design of airport infrastructure projects, including runways, taxiways, aprons, buildings, and utilities.	
As part of an Engineering Team, you will be responsible for the design of civil and municipal engineering projects for highway and local roads, public utilities and public works, and related infrastructure projects.	
Preparation of civil / environmental engineering construction and permitting drawings	
Designs portions of a project using relevant office software	
Perform routine aspects of engineering design work	
Ability to prepare design engineering drawings	
Complete design of transportation improvement projects	
Provide the highest quality planning, environmental and engineering design solutions to our clients.	
Perform engineering design	
Areas of practice will include general civil design	
Assisting senior design personnel in developing and completing designs.	
Attention to detail	
Possess an eye for detail	
preparing high-quality detailed design drawings	

Incidents	Sub-Category
Perform constructability reviews and interpret drawing	Sensitive Design
Participates on a team to produce decisions that balance safety, mobility, environmental impacts, property impacts, cost and long term maintenance.	

Incidents	Sub-Category
Consistently think beyond their basic engineering training to thoughtfully and creatively design structural solutions.	Creative Design
Ability to think in the abstract, versus having an entirely theoretical approach to problem solving, as the nature of this position deals with Traffic Operations & practical applications not always found in a manual.	
Creativity - Addresses objectives and problems while questioning traditional assumptions/solutions to generate creative ideas and new ways of doing business; exhibits creativity and innovation when contributing to organizational and individual objectives; seeks out opportunities to improve, streamline, reinvent work processes.	

Incidents	Sub-Category
	Design Alternative
Develops preliminary engineering concepts and alternatives for review and evaluation by the Project Engineer.	
Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems.	
Lead the planning, evaluation and selection of preferred alternatives	
Analyzes challenges, defines successful solution alternatives and proactively solves problems.	
Participates in engineering studies of transportation system improvements and develops alternatives for meeting the goals of the identified improvement.	

Incidents	Sub-Category
prepare construction drawings per clients standards	Plan Development
assist in preparing plans	
Preparing documentation including plans	
Preparation of construction documents	
An understanding of design plans	
Assist with the preparation of engineering plans,	
prepare engineering and design documents	

Incidents	Sub-Category
This position is in the Transportation Planning group and focuses on developing long-range multimodal area transportation plans, including plans for east, west, and downtown San José.	Planning and Development
We are looking for an enthusiastic Graduate Engineer to fill an opening within our Airport Planning and Design practice center	
Performs field observations of construction where appropriate.	
This position assists in the planning and designing of civil site projects.	
Your primary purpose is to work with external partners to create transportation plans to serve future travel needs.	
A basic familiarity with transportation planning and project development activities a plus	
Prepare engineering studies, feasibility reports, engineer evaluations	
Ability to visualize projects through both hand and digital graphic techniques.	
The primary activity of the Mining and Energy Group is developing and implementing technical solutions to today’s mining and energy issues.	
provides comprehensive consulting, engineering, and analysis for electric power generation and power delivery projects worldwide.	
Perform engineering studies, analysis and design.	
aerial photographs, satellite imagery and mapping and planning analysis	
Lead the planning, evaluation and selection of preferred alternatives	
Organizes and conducts engineering investigations and planning work	
This position is in the Transportation Planning group	
This position assists in the planning and designing of civil site projects.	

Incidents	Sub-Category
	Preliminary Concepts
Ability to read, comprehend, and prepare construction drawings	
Prepare sketches and diagrams.	
Prepares sketches and coordinates with Designers/Drafters in the development of design drawings	
Experience in preliminary design	
Prepare conceptual designs	
Provide quality design illustrations	
Perform conceptual and detailed design calculations and analyses	
Complete preliminary layout of transportation improvement projects	
Provide sketches and/or detailed layout information to design staff for incorporation into the construction drawings.	

Incidents	Sub-Category
Defining project scope and manage resources	Project Scope
Participate in planning for assigned projects	
Experience in planning	
Demonstrated project setup skills	

Incidents	Sub-Category
Maintains good knowledge of governmental regulations, codes and ordinances and applies them to plans, as needed.	Project Need
Your primary purpose is to work with external partners to create transportation plans to serve future travel needs.	
Ability to work with general public, professional, consultants, and staff, with sensitivity to their needs, priorities, promises made and commitments.	
Ability to prepare clear and concise written reports suited to the needs of the audience.	
Communicate with clients to determine their project needs.	

Incidents	Sub-Category
Manages, organizes, and oversees civil designs	Project Delivery
Plans, designs, and directs engineering projects	

Incidents	Sub-Category
Support and analysis high fidelity modeling of complex structures and systems	Project Complexity
Work involves interpreting semi-complex ordinances and specifications,	
Exercises independent engineering judgement for decision making that is appropriate for the complexity	
This position requires an individual capable of applying engineering principles in the design development process of highways and transportation improvement projects of a broad scope and complexity.	

Incidents	Sub-Category
Good attention to details and accuracy of work	Project Risk
Projects worked on will be from concept design, through to construction	
Performs construction quality assurance, contract administration, permit inspection and compliance, utility relocation coordination and inspection.	

Incidents	Sub-Category
Prepare environmental impact studies	Environmental Impact

Incidents	Sub-Category
Experience performing environmental due diligence investigations	Environmental Investigation
Performing and managing environmental subsurface investigations.	
Organizes and conducts engineering investigations and planning work	

Incidents	Sub-Category
a desire to learn a variety of tasks in both engineering and environmental disciplines	Environmental Engineering
Thorough understanding of the environmental rules that apply to construction projects.	
For this position, we are looking for someone with an emphasis in environmental or water resources design,	
Inform clients of environmental issues.	
You would be a member of a team providing environmental consulting services ranging from site investigations to remediation projects.	
Be familiar with environmental and licensing processes and how to coordinate issues in the transmission line design process.	
An understanding of or familiarity with NPDES regulations and permits, would be beneficial.	
Provide National Pollutant Discharge Elimination System (NPDES) permitting support to internal (ERM) and external clients.	
Experience in National Pollutant Discharge Elimination System (NPDES) permitting and compliance,	

Incidents	Sub-Category
Site Mitigation	Environmental Mitigation
Ability to work at environmental remediation,	
Some support on environmental remediation projects.	
experience with contaminated sediments, river, and estuary restoration	
Advise corporations and government agencies of procedures to follow in cleaning up contaminated sites to protect people and the environment.	
As an intern in the Resource Disposal and Recovery Services (DRS) group, you can expect to carry out a variety of different tasks related to solid waste disposal facility engineering, permitting, construction, and/or environmental compliance.	
application of traffic calming, neighborhood design	
The Envision 2040 General Plan embraces "planning for people, not just cars" and "creating walkable and bike friendly neighborhood villages" to transform San José from a suburban city dominated by the automobile into an interconnected and vibrant city.	

Incidents	Sub-Category
Assisting with environmental documentation	Environmental Documentation

Incidents	Sub-Category
understanding of technical specifications is value added	Specifications
Preparing documentation including specifications	
An understanding of specifications	
Maintains good knowledge of governmental regulations, codes and ordinances and applies them to plans, as needed.	
Provides plan review and engineering analysis of proposed designs for public land development to ensure compliance with all laws, guidelines, codes and regulations.	

Incidents	Sub-Category
Gathers preliminary documentation (inventory maps, circuit maps, look-ups, load data, etc.)	Data Collection
Implement applications and processes to integrate project data	
gather data from existing drawings, rough sketches, surveys, and/or from general engineering and design information	
Collection of traffic and highway field data.	

Incidents	Sub-Category
Collect and efficiently manage various forms of geospatial data	Data Management
develops, manages, and maintains statewide data for highway corridor planning, environmental analysis, long-range planning	

Incidents	Sub-Category
Collect, organize, and evaluate data.	Data Analysis
Collect, analyze, and summarize transportation and related data	
Research for preliminary reports	
Ability to and experience in analyzing and interpreting geospatial data	
Developing and interpreting data	
Ability to read, analyze and interpret common scientific and technical journals	
Analyzes maps, drawings, blueprints, and aerial photographs	
Ability to read, analyze, and interpret general business periodicals, professional journals, technical procedures, or governmental regulations.	
Analyze sketches, drawings, notes, and/or verbal information	

Incidents	Sub-Category
Strong understanding of how to extract data out of multiple formats	Data Aggregation

Incidents	Sub-Category
Collaborating with other groups	Collaboration
The essential functions of this position include working collaboratively on various telecommunications projects	
Welcome the collaborative and iterative process that comes with designing world class buildings and public spaces	
Ability to work collaboratively in diverse teams including technical and non-technical personnel	
Collaborate with project managers and design staff to provide status updates, discuss challenges, and address plan revisions	
Able to collaborate across functional boundaries to improve business processes.	
Coordinate with key stakeholders on large scale projects.	
work as an integrated member of a team and collaborate effectively with others	
Ability to interface with others to resolve any challenges.	
Work with government agencies and public authorities as required to provide support for land surveying and mapping.	

Incidents	Sub-Category
Coordinates with others when directed by supervisor or project leadership.	Coordination
Coordinate with other disciplines.	
Strong understanding of how to coordinate drawings between disciplines and ability to identify drawing conflicts between the disciplines	
Coordinate with multiple engineering disciplines to assist in development of conceptual to final civil design for industrial, military, municipal, international, and private clients.	
Collaborate with key stakeholders on large scale projects.	
This position will fulfil key technical roles by effectively coordinating with City staff, partner and neighbor agencies, and community members.	

Incidents	Sub-Category
working with other project team members to provide quality service to clients	Project Teams
work effectively within project teams	
Ability to work in team environment.	
Interact with coworkers, project teams	
will be expected to participate on project teams	
Ability to work effectively in a team situations;	
Contributes effectively toward team goals	
ability to work as a member of a multi-disciplined team, work with diverse clients	
You will have the ability to team and work on projects with clients such as Texas Department of Transportation and municipalities	
Participates on a team to produce decisions that balance safety, mobility, environmental impacts, property impacts, cost and long term maintenance.	
Work within multidiscipline design teams	
Work within multidiscipline design teams on wide variety of civil, civil / environmental and A / E projects,	
Participates as a member of a design team on projects as assigned by the Project Manager.	
Assist the Project Team in technical meetings and correspondence with clients.	
You will interact with other disciplines, clients, contractors, and regulatory agencies.	

Incidents	Sub-Category
work as an integrated member of a team and collaborate effectively with others	Building Effective teams
work effectively within project teams	
Ability to work effectively in a team situation	
Contributes effectively toward team goals	
Develop positive relationships with co-workers, clients, citizens, regulatory agencies and contractors through tactful and effective communication	

Incidents	Sub-Category
Daily contact with the public to provide information about proposed work and project status, and to respond to complaints	Public Education
Work with community liaison to inform public about upcoming work and potential impacts.	
Provide information to internal and external customers by extracting data from databases	
Develop documents, maps and other materials as required that explain this information to those individuals who often do not have expertise in the area of transportation	
Helpful Experience: Public presentation	

Incidents	Sub-Category
Outreach: Coordinating outreach for projects.	Publicity
Has strong outreach and communication skills and can and effectively interact with various stakeholders in situations that are sometimes controversial and/or ambiguous.	
Coordinating education and outreach efforts	
Aid in community outreach efforts.	
Support testimony and attendance to public meetings as required to support the permitting process.	
Social Awareness - Demonstrates the ability to read or sense other people’s emotions and how they influence the situation of interest or concern; demonstrates empathy and organizational awareness.	

Incidents	Sub-Category
Obtains input from stakeholders	Public Input
Conduct special study work and participate in public involvement process	
Represent traffic on technical committees and participate in public involvement programs	
Work closely with internal and external stakeholders	
may participate in meetings with public officials and the public at large to answer questions and to advise on alternative methods to secure corrective action	

Incidents	Sub-Category
Ability to interact effectively with a wide variety of people	
Interact with internal and external clients/committees, including public and private agencies, citizens, or other affected interest groups	Public Interaction
Handling citizen complaints of safety issues along State roads	
Represent the City at various public forums and meetings.	
Meet with citizens, public officials, other government agencies, to exchange information, represent the county's interests, and ensure compliance with county policies.	
This position interacts with City staff, City residents, contractors and sub-contractors.	
Make public presentations, presentations and answer project specific and policy questions and to write letters and other documentation.	
Respond to contractors, clients and citizen questions and concerns and mediate conflict.	
Attend client and community meetings.	
Communicate regularly with officials at all levels within the City administration; City departments; local, regional, and state planners, engineers, and the public.	
Ability to represent the interests of the City and public safety in communication with the general public or agency representatives.	
meet with government officials, consultants, contractors and the general public regarding necessary design changes	
This position will represent the County's interests to engineers, local government, State and Federal agencies, and the public for traffic safety and mobility issues.	

Incidents	Sub-Category
Ability to work cooperatively and effectively with the public, businesses, elected officials and other governmental organizations.	Public Partnership
Each day, we partner with transportation agencies and local governments across the country to keep our communities moving and improving the overall quality of life.	
Ability to work with general public, professional, consultants, and staff, with sensitivity to their needs, priorities, promises made and commitments	

Incidents	Sub-Category
	Technical Communication
Completion of transportation planning reports,	
Prepare reports including text and exhibits, make presentations	
prepare investigation reports	
Assist in preparing formal engineering reports.	

Incidents	Sub-Category
Communicates status, updates, and expectations to project stakeholders.	Interpersonal Communication
Communicate regularly with officials at all levels within the City administration; City departments; local, regional, and state planners, engineers, and the public.	
Have interpersonal skills that allow free flowing and creative communication to understand and resolve the issues of all levels of stake holders.	
Able to communicate and interact with all levels of management and associates	

Incidents	Sub-Category
Must be able to read, write, and speak English at a professional level	Correspondence
The ideal candidate will have strong communication skills	
Candidates must have excellent communication, and presentation skills.	
Preparing documentation including correspondence	

Incidents	Sub-Category
Excellent verbal and written communication skills	Verbal Communication
Strong verbal and written communication skills a must.	

Incidents	Sub-Category
Technical Report Writing	Technical Writing
Write technical work documents, white papers, and technical positions	

Incidents	Sub-Category
Ability to prepare clear and concise written reports suited to the needs of the audience.	Written Communication
Excellent written communication skills	
report writing and review	
Preparing documentation including reports	

Incidents	Sub-Category
Excellent graphic communication skills	Graphical Communication

Incidents	Sub-Category
Can write and/or speak Spanish/Vietnamese.	Bi-Lingual
Bi-Lingual in Spanish & English a plus	
Required Language: English & Chinese	
Bilingual in English (Fluently) and Mandarin (Native), Cantonese is a plus	

Incidents	Sub-Category
Effectively communicate design details to field personnel and contractors.	Effective Communication
Ability to effectively present information to top management, public groups and/or boards of directors.	
Ability to effectively present information and respond to questions from groups of managers, clients, customers, and the general public.	
Communicate tactfully and effectively, verbally and in writing.	
ability to read, speak and write English clearly is required	
Communication Skills - Effectively conveys information and clearly expresses thoughts and facts, orally and in writing; demonstrates effective use of listening skills; displays openness to other people's ideas and thoughts	
Perform effective technical writing and correspondence	
This position will fulfil key communications roles by effectively coordinating with City staff, partner and neighbor agencies, and community members.	
Strong written, verbal, technical, and interpersonal skills	
Employing strong verbal and written communication skills with a high degree of professionalism	
Explaining complicated technical problems in simple non-technical language.	
Ability to communicate thoughts and technical ideas in an accessible way	
Perform effective technical writing and correspondence	

Incidents	Sub-Category
Ability to actively listen to others for understanding of their needs and situations	Listening
You are a great listener	
The ability to listen to and understand information and ideas presented through spoken words and sentences.	

Incidents	Sub-Category
make public presentations, presentations and answer project specific and policy questions and to write letters and other documentation.	Presentation
Assist a Senior Engineer with graphic presentation	
Communications: Communicating with members of the public, city, and neighbor and partner agencies.	
Prepare and present project information at training courses, industry meetings, department meetings, client meetings, etc.	
Excellent facilitation, presentation, and communication skills, both written and oral	
presenting the results of field sampling activities	
Helpful Experience: Public presentation	
Present project specific solutions to civil engineering clients	
Presents project details to clients, team members, and professional organizations.	
Assist in the preparation and submittal of various regulatory reports and documentation including annual reports, incident reports, safety related condition reports, and other documentation as needed.	

Incidents	Sub-Category
Develop documents, maps and other materials as required that explain this information to those individuals who often do not have expertise in the area of transportation	Knowledge Barrier to Communication
Explaining complicated technical problems in simple non-technical language.	
Ability to communicate thoughts and technical ideas in an accessible way	

Incidents	Sub-Category
Can write and/or speak Spanish/Vietnamese.	Language Barrier to Communication
Bi-Lingual in Spanish & English a plus	
Required Language: English & Chinese	
Bilingual in English (Fluently) and Mandarin (Native), Cantonese is a plus	

Incidents	Sub-Category
Has strong outreach and communication skills and can and effectively interact with various stakeholders in situations that are sometimes controversial and/or ambiguous.	Emotional Barrier to Communication
Demonstrates the ability to read or sense other people's emotions and how they influence the situation of interest or concern; demonstrates empathy and organizational awareness.	
Respond to contractors, clients and citizen questions and concerns and mediate conflict.	

Incidents	Sub-Category
Must possess a strong work ethic	Work Ethics
Able to demonstrate commitment to compliance with applicable laws and regulations, the Company's Ethics and Compliance Code of Conduct	
Represents the Company at all times with high moral standards while adhering to the Company's "Code of Business Conduct and Ethics	
Ability to maintain discretion and confidentiality at all times	
Strong work ethic	
Highest work/personal ethics and integrity;	
Conduct work in a professional and ethical manner	

Incidents	Sub-Category
Able to represent Company in a professional manner in matters and meetings with both private and public, entities and officials.	Professionalism
Ability to perform work in a professional demeanor.	
Must be professional with good communication skills to represent RGE in a professional manner while off site.	
Demonstrate the firm's core values in decision and interactions Conduct work to professional standards	
Knowledge of standard professionalism practices and procedures.	
Conduct work in a professional and ethical manner	

Incidents	Sub-Category
Assist in establishing project budgets.	Budgeting
Performing tasks according to assigned schedule and budget	
Helpful Experience: Budget tracking	
Complete Transportation Capital Improvement Program (CIP) budget activities.	

Incidents	Sub-Category
Perform cost and schedule estimates for projects	Cost Estimating
Preparing documentation including cost estimates	
prepares detailed cost estimates	
Provides project cost estimating.	
Prepare cost estimates	

Incidents	Sub-Category
Developing and formulating cost-effective solutions	Value Engineering
providing quality, cost-effective design solutions to public and private sector clients	
Apply value engineering principles to proposed utility designs	
Performs computations and analyses of cost-benefit engineering considerations.	

Incidents	Sub-Category
Verify accuracy of payment requests and invoicing for completed work	Accounting
Reviews completed work orders and cost data to assure conformance with plans and acceptability of construction charges.	
Helpful Experience: invoicing	
Prepare invoice.	
Pursue aged accounts.	

Incidents	Sub-Category
Prepare applications to secure external funds.	Investment
Have the ability to apply for and capture State and Federal grant monies for funding large projects.	
Assist with County's efforts in obtaining State/Federal funding for the project	

Incidents	Sub-Category
Prepare feasibility studies	Economic Justification
Researches feasibility of alternative design approaches	
Assists in economic justification studies for proposed engineering facilities	
The assignments may include Site feasibility report preparation	
Estimate quantities and cost of materials, equipment, or labor to determine project feasibility.	
Prepares economic justification for each project proposed to assist management with evaluation of capital investment.	
Make comparative Engineering and Economic evaluations	
Evaluate multiple solutions for economic, timing, and political constraints to determine the optimum choice.	

Incidents	Sub-Category
Experience in working with regulatory agencies.	Regulatory Knowledge
knowledge of State and Federal environmental laws and regulations	
a strong understanding of standards	
familiarity with standard industry practices	
ensure requirements of codes and specifications are met	
Stay abreast of and ensures compliance with local, State, and Federal rules and regulations.	
Keeps abreast of changing codes, regulations	
Knowledge of Federal and State highway preliminary design and final design standards, specifications, rules, and environmental regulations.	

Incidents	Sub-Category
Research and review deeds, ordinances, municipal, state and federal codes to ensure compliance	Legal Research
Researches regulatory agency specifications	
Researches regulations	

Incidents	Sub-Category
Basic knowledge and application of FAA Advisory Circulars	Statutory Knowledge
Ability to learn Tennessee Department of Transportation (TDOT) standards, policies, and procedures.	
Familiarity with governing State and National codes and standards	
Experience in working with MDNR, MNDOT, Corps of Engineers and other regulatory agencies.	
Knowledge of Building code and construction regulation is a plus	
Knowledge of applicable County policies, laws, and regulations	
Reads and interprets survey data, legal description, government standards and codes,	
Familiarity with municipal land use law is a plus;	
Knowledge of international law, federal laws, statutes and regulations of merchant marine operations.	
Basic knowledge of public transportation agency (IDOT, Tollway) and utility (natural gas/electric) standards	
Reading comprehension of laws, rules, policies and procedures	
Knowledge of highway design standards	
Learn union rules and agreements and apply to crafts under jurisdiction	
Knowledge of federal and state laws and regulations pertaining to design, construction, and the environment.	
They, then, are familiarized with the legal side of the project by putting together documents such as easements, restrictive covenants, license agreements and more.	

Incidents	Sub-Category
Prepare legal documentation	Legal Documentation
Ability to administer major multi-part contracts.	
Assist a Senior Engineer with contract documentation preparation	
Assisting senior design personnel in developing and completing contract documents.	
Assist in the preparation of contract	
Administers agreements for construction	
Proposal/Contract Preparation	

Incidents	Sub-Category
This engineering position will be responsible for assuring that subdivision, construction, and commercial entrance plans meet current DelDOT standards and regulations.	Legal Compliance
Responsibility for contract compliance and administration on contracts associated with the project.	
The position requires identification, development, evaluation, implementation and management of BIM standards and procedures.	
Coordinates with government officials to obtain required approval and permits	
Work involves interpreting semi-complex ordinances and specifications,	
Review Contract documents, engineering plans, and technical specifications to ensure compliance with governmental regulations	
Maintain engineering standards and procedures.	
Ensure that assigned projects are completed within the guidelines established by local, state, and federal laws, regulations, standards, and/or policies.	

Incidents	Sub-Category
Excellent customer service skills, with an understanding of customer relationship building	Business Sense
You have an entrepreneurial spirit with a desire to learn and grow.	
Participate in business development and outreach opportunities to solicit and acquire new work.	
Our business field includes cross-border logistics and transport systems	
Knowledge of those with whom the Public Works Department conducts business, such as city, state and federal agencies, contractors and suppliers.	
Responsibilities Our Nuclear Power Technologies business unit currently has an opportunity for an entry level Structural Engineer.	
Support business development activities.	
Able to cultivate relationships and partner with business and community contacts to achieve business results.	
Knowledge of the Company's business systems, operating standards and replacement programs	
Ability to negotiate mutually acceptable solutions and build consensus through give and take	
develop important relationships with local city staff that in turn facilitates the ongoing relationship	
Engage in marketing and networking activities at conferences and other industry gatherings.	
Excellent networking skills	

Incidents	Sub-Category
Ability to build and maintain excellent interpersonal relationships.	Interpersonal Skills
Excellent interpersonal skills	
Excellent interpersonal skills and the ability to establish and maintain client relationships	
Is socially and politically adepts.	
Interpersonal and relationship building skills	
Develop positive relationships with co-workers, clients, citizens, regulatory agencies and contractors through tactful and effective communication	

Incidents	Sub-Category
provide quality service to clients	Client Management
strong business acumen	
Assist in preparing and present proposals.	
Render advice to clients.	
Communicate with clients to determine their project needs.	
Attend onsite and offsite client meetings which may be local, continental U.S. or international.	
Respond to civil engineer clients on project-specific inquiries	
Have awesome customer service skills coupled with a sincere desire to provide service to the community.	
basic understanding of external client's main interests and drivers	
Establish and maintain rapport with civil engineer clients.	
Ability to build and maintain strong client relationships.	
This includes providing primary support, forecasting, conducting customer support meetings and ensuring regular communication with the customer.	
Assists in client contact and communication, and attends client meetings	
You are customer focused.	
demonstrated commitment to excellence in customer service	
Experience with both private and public sector clients/projects	

Incidents	Sub-Category
investigations to identify existing utilities and determine scope of potential conflicts	Utility Impact
Analyze roadway design plans and utility construction proposals to evaluate resolution of conflicts with existing and proposed utilities	
Researches site conditions.	
Perform utility relocation coordination and inspection.	

Incidents	Sub-Category
Conduct and document traffic studies	Transportation Impact
Research and prepare drafts of preliminary traffic studies	
Knowledge of traffic studies and data analysis	
Prepare and/or review transportation planning reports, traffic studies	
reviewing traffic impact studies for proposed developments	
Review and prepare written evaluation of traffic impact studies	
Support the review of development proposals, including Transportation Impact Assessments	
Analyzing congestion relief and highway capacity issues	
Handling pedestrian, school, and bicycle issues	
Assisting with land use and access studies, and other transportation studies including the appropriate public involvement, environmental documentation, agency coordination, and preliminary highway design	

Incidents	Sub-Category
Site new transmission line and be able to coordinate and asses the impacts of real estate, licensing and environmental constraints on the overall engineering process.	Land Development Impact
Completing on-site failure investigations, condition assessments, and litigation support (at new and existing construction) to evaluate problematic conditions; including survey and documentation of distress, field testing, sampling, photographing, and sketching	

Incidents	Sub-Category
ability to work independently on multiple projects	Multi-tasking
organized and able to prioritize multiple tasks	
Capable of working on multiple projects simultaneously.	
prioritization and multi-tasking ability	
Demonstrated ability to prioritize and multi-task	
Proven ability to manage multiple assignments, priorities, and projects in a demanding environment	

Incidents	Sub-Category
Independent, self-directed worker;	Initiative
Work independently on small projects	
this position comes a high level of freedom to be innovative	
Independent judgment on day-to-day work and decisions.	
Take ownership of projects, programs, and systems in the area of cognizance	
Ability to work independently	
Consistently think beyond rote training to thoughtfully and creatively design site solutions	
Exercise initiative, judgment and knowledge as required in areas of responsibility.	

Incidents	Sub-Category
Write proposals in response to RFPs for existing and new lines of business.	Contract Solicitation
Author project submittals	
Assist in preparations of bid packages and procurement	
Manage procurement documentation for all contractors to be hired	
Development and delivery of proposals for quoted work projects	

Incidents	Sub-Category
Helpful Experience: Proposal writing	Contract Proposals
writing high-quality proposals	
Assist with the development of project proposals and develop project budgets	

Incidents	Sub-Category
resolve issues and problems in a constructive manner	Problem Solving
Problem solving and project delivery specialist	
Ability to define problems	
Excellent reasoning, investigative, analytical, and problem solving ability	
strong problem-solving skills	
develop approach to solutions	
Ability to take initiative to solve problems in an innovative manner	
Attention to detail, Interpersonal skills Mathematical skills Problem solving skills	
Able to identify solutions to problems with creativity and innovative thinking.	
using subject matter knowledge and innovation to offer high-quality solutions to our clients	
Achieve results and solve problems under own initiative	

Incidents	Sub-Category
capable of making rapid decisions with input from senior staff	Decision Making Judgement
Make decisions regarding methods	
Able to make sound decisions based on engineering and operational principles	
Ability to establish facts and draw valid conclusions.	
Exercises independent engineering judgement for decision making that is appropriate for the complexity and scope of entry-level tasks.	
Consistently exercise discretion and judgment in all work tasks.	

Incidents	Sub-Category
Strong planning, organization, preparation, and execution capabilities	Competencies
Must possess strong human relations, communication, interpersonal and judgment skills.	
negotiate conflict resolution	
Ability to organize, analyze and evaluate available information and draw reasonable conclusions	
Ability to plan, budget, schedule, and direct construction	
Strong interpersonal, communication, analytical and problem-solving skills	
Understands and adheres to budget, schedule, and quality requirements.	

Incidents	Sub-Category
Demonstrated leadership skills	Leadership
understands causal mechanisms, recommends appropriate action, owns problem resolution and documents results	
Independently develops and/or supervises the creation of engineering products that meet customer quality requirements for various DOT road and highway projects	
Have demonstrated leadership and engagements outside the classroom and in their communities.	

Incidents	Sub-Category
Analytical Thinking - Approaching a problem or situation by using a logical, systematic, sequential approach.	Analytical Thinking
Ability to read and apply critical and analytical thinking	
ability to think critically through a project from conception to completion	
strong analytical skills	
Strong analytical and problem solving skills.	

Incidents	Sub-Category
Participate in scheduling for assigned projects	Time Management
a willingness to modify personal schedules as required to meet client needs	
Schedule project deliverables.	
Organizes and prioritizes work flow in order to meet project time lines.	
ability to do what it takes to complete projects on time, on budget,	
Have strong time management skills to effectively manage workload	
Strong time and project management skills	

Incidents	Sub-Category
This position exists to provide project management responsibilities for projects or tasks ranging from Minor Projects to Moderate Projects	Management
Able to demonstrate effective project management and time management to meet project deadlines and remain within budget.	
Occasionally perform project management tasks.	
Perform administrative duties associated with project management for civil/site projects	
Project Management (Limited)	
Must have solid skills in the following areas: planning and scheduling; organization; problem solving; and decision	
Strong project management skills and experience Education Requirements	
This individual will assist Project Managers with the planning, design and construction of various municipal, transportation, and utility projects.	
willingness and ability to perform a wide range of project tasks	
may act as liaison on major engineer projects and serve as project manager on major repair work	
Coordinates project activity with appropriate officials	

Incidents	Sub-Category
Excellent organizational abilities	Organization
Strong organizational abilities	

Incidents	Sub-Category
Coordinate technicians to perform field tests.	Team Management
Oversee and maintain project team and in-house communication during work performance.	
Focuses on the needs of internal clients	
Oversee and maintain project team and in-house communication during work performance.	
This position will fulfil key communications roles by effectively coordinating with City staff, partner and neighbor agencies, and community members.	

Incidents	Sub-Category
Manage contracts with subcontractors	Contract Management

Incidents	Sub-Category
Coordinate design activities to ensure installation and operations will comply with specifications, codes, and client requirements.	Engineering Principles
Ability to function as a project engineer	
This position requires an individual capable of applying engineering principles in the design development process of highways and transportation improvement projects of a broad scope and complexity.	
able to apply engineering knowledge toward solving assigned tasks	

Incidents	Sub-Category
Effectively conveys information and clearly expresses thoughts and facts, orally and in writing; demonstrates effective use of listening skills; displays openness to other people's ideas and thoughts	Share Information
Have interpersonal skills that allow free flowing and creative communication to understand and resolve the issues of all levels of stake holders.	

Incidents	Sub-Category
This position will fulfil key communications roles by effectively coordinating with City staff, partner and neighbor agencies, and community members.	Manage Relationships
Must possess strong human relations, communication, interpersonal and judgment skills.	
Develop positive relationships with co-workers, clients, citizens, regulatory agencies and contractors through tactful and effective communication	

Appendix A2

FOCUS GROUP OPEN CODING

Incidents	Sub-Category
Should teach the core design courses but also include constraints and societal effects	Sensitive Design
Design standards and development practices that are flexible and sensitive to community values. Context Sensitive Solutions allows design decisions to better balance economic, social and environmental objectives.	

Incidents	Sub-Category
Thinking outside the box	Creativity
Should be allowed to use Creativity	

Incidents	Sub-Category
Students must learn: how to develop a reasonable range of alternatives	Design Alternatives

Incidents	Sub-Category
Work breakdown	Project Scope
Critical path / CPM	
Project scoping	
Project planning	
Ability to scope a project	
Students will learn how to identify potential issues;	
Transportation planning (e.g., travel forecast modeling)	

Incidents	Sub-Category
Skills necessary to identify the actions needed for a thorough environmental analysis and mitigation.	Project Need
An ability to design a system, component, or process to meet desired needs within realistic constraints.	

Incidents	Sub-Category
Delivery methods	Project Delivery
Project delivery methods (e.g., design-bid-build, design build, construction management, multiple prime)	
Project Delivery	
Students should understand control measures and systems to effectively delivery of a project.	

Incidents	Sub-Category
Risk analysis	Project Risk
QAQC	
Process Quality Management	
Risk Management	

Incidents	Sub-Category
HSE (Health Safety Environmental) issues	Environmental Impact
Noise Pollution	
Air Pollution	
NPDES design certification	
RAP	
Construction contingency plans	
Environmental stewardship looks at the National Environmental Policy Act (NEPA). It looks at impacts, mitigation and documentation.	
Students must learn: how to develop public involvement strategies; how to develop a systematic process for quantitatively and qualitatively predicting effects; and, the skills necessary to identify the actions needed for a thorough environmental analysis and mitigation.	

Incidents	Sub-Category
Environmental investigation	Environmental Investigation
Historical understanding	

Incidents	Sub-Category
Knowledge of Environmental compliance Regulation	Environmental Engineering
Clean water act and all parts of it	

Incidents	Sub-Category
Students will learn: the various levels of NEPA documentation;	Environmental Documentation
Wetlands	
Historical preservation	
NEPA Process	

Incidents	Sub-Category
Sustainable land management (SLM) is a knowledge-based procedure that aims at integrating the management of land, water, biodiversity, and other environmental resources to meet human needs while sustaining ecosystem services and livelihoods.	Sustainability
An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	
Sustainable site development	

Specifications	Sub-Category
assist in preparing plans, specifications, and reports	Specifications
Understanding what is a spec.	
Specifications and BoQ	
Standard and Spec. Reading	
MnDOTSpecs	
CSI formats	
PSE package	

Incidents	Sub-Category
Ability to gather pertinent information	Data Collection
Effectively access information	
Gather information	

Incidents	Sub-Category
Ability to work with contractors	Collaboration
Good at Coordination	

Incidents	Sub-Category
An ability to function on multidisciplinary teams	Project Teams
Team Player	
Team Projects	

Incidents	Sub-Category
Students should be prepared to present their work in a public forum.	Public Education

Incidents	Sub-Category
Learn to justify projects for public buy-in	Publicity

Incidents	Sub-Category
Students will learn: how to develop public involvement strategies	Public Input

Incidents	Sub-Category
Learn to conduct open house events.	Public Interaction

Incidents	Sub-Category
Technical Writer	Technical Communication

Incidents	Sub-Category
Learning to speak up	Verbal Communication
Oral communication	

Incidents	Sub-Category
Written Communications	Written Communication
Writing Skills	

Incidents	Sub-Category
Graphic tools will be introduced and used in the presentation course.	Graphical Communication

Incidents	Sub-Category
An ability to communicate effectively	Effective Communication

Incidents	Sub-Category
Presentation skills	Presentation
Presentation	
A specific presentation course should be offered in the first year of the program.	

Incidents	Sub-Category
An understanding of ethical responsibility	Work Ethics
Ethical Standards	

Incidents	Sub-Category
Professional	Professionalism
An understanding of professional responsibility	

Incidents	Sub-Category
Budgeting	Budgeting

Incidents	Sub-Category
Estimating	Cost Estimating
Basic cost estimating (mentioned 3 times)	
Cost estimation	
Material estimating and project estimating	
Construction cost estimating (mentioned twice)	
Ability to complete engineering cost estimates	
Basic cost estimating (mentioned 3 times)	

Incidents	Sub-Category
Value analysis	Value Engineering
Conduct value engineering studies	
Project cost comparison	

Incidents	Sub-Category
Financial management/accounting	Accounting

Incidents	Sub-Category
Understand funding structure	Investment

Incidents	Sub-Category
Engineers seek solutions to problems, and the economic viability of each potential solution is normally considered along with the technical aspects.	Economic Justification

Incidents	Sub-Category
Principles of construction contracts	Legal Knowledge

Incidents	Sub-Category
Know how to find regulations and state and federal codes.	Legal Research

Incidents	Sub-Category
Basic contract law	Legal Documentation
Government contracts	
Introduces the student to the technical and legal documents that are used in the construction industry.	

Incidents	Sub-Category
Knowledge of permitting process	Legal Compliance
Should be able to interpret ordinances, codes and specifications	

Incidents	Sub-Category
Have good Business skills	Business Sense
Have a sense of Entrepreneurship	
Knowledge of how different agencies work	
business acumen	

Incidents	Sub-Category
Need to know how to interact with other workers and the public.	Interpersonal Skills

Incidents	Sub-Category
Communicate with clients	Client Management
Design build is causing civil engineers to work with engineers from different counties.	

Incidents	Sub-Category
Transportation planning (e.g., travel forecast modeling)	Transportation Impact Studies

Incidents	Sub-Category
Effective site development	Responsible Site Development
Responsible Site development	
Contextual Site Planning/development	
Site development permitting	
Introduce students to the manner in which land development engineers must consider planning, environmental, and sustainability issues.	

Incidents	Sub-Category
How to quantify bid items	Contract Solicitation
Put together a proposal	

Incidents	Sub-Category
An ability to identify, formulate, and solve engineering problems	Problem Solving
Problem Solver	
Learning to see problems from many angles/ all sides	
Problem Solving	
Holistic approach to engineering problem solving	
Can pull resources to solve unique problems	
Innovative solutions to problems	

Incidents	Sub-Category
Demonstrate good engineering judgement	Decision Making Judgement

Incidents	Sub-Category
PS & E Competence	Competencies
Knowledge of different agencies	
Conflict management	
Ability to conduct a meeting	
Global Competence	

Incidents	Sub-Category
Leadership Skills	Leadership

Incidents	Sub-Category
Think critically about information	Analytical Thinking
Critical thinking skills	

Incidents	Sub-Category
CPM scheduling	Time Management
Scheduling (Microsoft Project)	
Time management skills	

Incidents	Sub-Category
Project Management (mentioned 4 times)	Management
How to manage a project	
Project Management skills (mentioned twice)	
Knowledge in project management S	
Project process and development	
Science of management	
Furnish students with the skills and knowledge they need to plan, schedule, and understand control measures and systems to effectively manage a project.	

Incidents	Sub-Category
Provide an introduction to construction contracts management	Contract Management

Incidents	Sub-Category
Knows the theory behind principles	Engineering Principles
Understand other major engineering disciplines	

Appendix A3

CASE STUDY OPEN CODING

Incidents	Sub-Category
This internship will help us to manage a major upgrade at the Heywood Campus, in particular, developing and implementing plans for maintenance and transportation improvements, as well as manage new smaller projects that come up during the summer.	Need for Project
Engineering and Construction has a backlog of funded projects. Some of the work that would be assigned to this internship is: Various sustainability projects; various water resources projects; Pedestrian barriers @ Rice St. & 4th St; various bridge maintenance projects; and assist in the Park & Warehouse Crossovers Project.	
This internship will help us to catch up on some of the normal work load, in particular, developing and implementing plans for scheduled preventative maintenance projects, as well as manage new projects that come up during the summer.	
Some of the work that would be assigned to this internship is: APTA Peer Recommendations (including pedestrian channelization, standardization of pedestrian signage, and pedestrian railing extensions at various platform locations.	
The landscape asset inventory is a new effort to improve the design and maintenance of landscaping at transit facilities, resulting in lower costs, better environmental stewardship, and more attractive facilities for customers and communities.	
Project participation will include engineering services and site inspections on Better Bus Stop projects, Park and Ride renovation projects and Transit Center renovation projects.	
The Metro Transit Facilities and Police departments are in need of additional space to facilitate their daily operations.	
Project participation will include engineering services during construction of MTPD and OSC remodel; and design of Nicollet Garage Wall Repair; MJR Interior Wall Painting; South Pit Fill; East Metro Below Ground Joint Repair.	
The internship is extended so that xxxx can continue the second year of her internship with E&F. She would continue to work on the Be the Solution program, sustainable waste project, renewable energy project, APTA Sustainability and Multi-modal Conference, water conservation projects (Rain water garden grant received for Transfer Road), grant application writing (water, storm water, electric vehicles), expansion of electric staff cars and charging stations, and reporting on our Sustainability efforts.	
This project is to perform construction services that will bring the Heywood II site in compliance with the City and Watershed stormwater better management practices.	
The project objective is to construct a maintenance and storage facility that will accommodate approximately 200 buses.	
The E & F Sustainability and Energy Work Group leads Metro Transit's sustainability initiatives as empowered by Thrive MSP 2040 and as required by State Statute and Executive Orders.	

Incidents	Sub-Category
Shop drawing	Detailed Design
Construction details	
Design blowouts	
Construction plans	
As-Built drawings	

Incidents	Sub-Category
Pedestrian bicyclists Accessibility	Sensitive Design
Accessible bus stops	
Aesthetically pleasing design and complement the character of their surroundings.	
Art in Public Places	
Sidewalk connection	
Midblock bus stops	
Curb extensions	
Street Calming	
Native vegetation	
Use of Recycled and biodegradable materials	

Incidents	Sub-Category
Station designs alternates	Design Alternatives
Garage Site selection	
Alternative energy	
We have provided three alternative solutions to meet your projected future parking demand of 1,400 to 1,800 spaces, to provide covered parking, and to reduce walking distance for patrons.	
Downtown Alternatives Engagement Summary and Comments Received	
Alternatives analysis study	

Incidents	Sub-Category
I have participated in the preparation and review of the Bidding Documents for this project and agree that the Bidding Documents represent items requested and/or agreed to for this project.	Plan Development
Plan review	
Plan assembly	
Design sidewalk connection from Naples St NE to boarding area at 95th Ave park and ride in Blaine. Would require coordination with City of Blaine project to connect to sidewalk along Naples St.	
Traffic signal revision design, using xxxx work order (xxxx desired by City of Maplewood and Ramsey County). This is a traffic mitigation required for our Maplewood ramp, but is separate from the larger construction project. The intern would probably be able to see this through construction as well.	
30 percent construction plans	
50 percent construction plans	
95 percent construction plans	
Final construction plans	

Incidents	Sub-Category
Assist with development of RFP, SOW, etc. for design project as well as for other required services (surveying, soils investigations, environmental evaluations, prep info for FTA submittals, etc.)	Planning and Development
Assist with development of RFP, SOW, etc. for design project as well as for other required services (surveying, soils investigations, environmental evaluations, prep info for FTA submittals, etc.) for all stations (Lake Street, 66th Street, American Boulevard, 98th Street, and Burnsville).	

Incidents	Sub-Category
Site plan rendering	Preliminary Concepts
Concept plans	
Concept drawing	
Layout plans	
Schematic design	
Design sketches	

Incidents	Sub-Category
Scope of Work DTE Pedestrian Bridge – Snowmelt System	Project Scope
SCOPE OF SERVICES •Review documents of underground piping system in construction at Ramsey Station •Visit Ramsey Station platform •Work with HyShee to design above ground heating system that will work in conjunction with underground piping system •Develop detailed cost estimate, schedule and specifications for construction	
Alternative scoping	
Summary of findings	
Project delivery options	
Feasibility Study	
Environmental Scoping Document	

Incidents	Sub-Category
	Creative Illustrations
Visual Simulation	
Photographic rendering	
Computer modeling	

Incidents	Sub-Category
This position will help the project managers maintain their project schedules and will assist in the group's overall work load demands.	Project Needs
Interns work on small projects and assist full time staff with other projects as needed.	
Assistance to the E&F department to provide additional staff hours to collecting data, evaluate project needs	
Procedures that aims at integrating the management of resources to meet project needs.	
Public presentation on project need and positive impact	
Cash flow needs analysis	

Incidents	Sub-Category
Identify, design, bid new ADA pad installations for the Spring of 2015.	Project Delivery
Design, bid, and construct replacement of duct insulation at the OHB	

Incidents	Sub-Category
This position will assist project managers on projects that vary in size and complexity	Project complexity
This position will assist project managers on projects that vary in size and complexity	

Incidents	Sub-Category
Mitigate the safety hazard created by pedestrians crossing the tracks mid- platform.	Project Risks
Estimating the Probability of a pedestrian collision.	
Peer review	
Construction insurance	
Bid Bonds	
Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion	
I have reviewed the bid documents xxxx Construction provided, along with the results from reviews conducted by the Purchasing office and by the office of Diversity and Equal Opportunity. Based on my review I find xxxx Construction to have adequate financial resources to perform the contract, is able to comply with regulatory requirements, is able to deliver according to the contract schedule, and has a history of satisfactory performance.	

Incidents	Sub-Category
Station and Support Facility Design Guidelines	Design Guidelines
Regional Transitway Guidelines	
Guideline for the Location and Design of Bus stop	
Manual on Pedestrian and Bicycle Connection to Transit	

Incidents	Sub-Category
It is the policy of the Metropolitan Council to plan effective regional transportation services and facilities, coordinate regional transportation priorities and to invest transportation resources in a cost-effective manner.	Project Resources
Engineering and Facilities is continuing ahead with the design of the New Minneapolis Bus Garage and additional resources are needed to help coordinate/manage the design between internal and external stakeholders and reviewers.	
Based on my review there is adequate financial resources to perform the contract.	
Defining project scope and manage resources	
Procedures that aims at integrating the management of resources to meet project needs.	

Incidents	Sub-Category
Floodplain Impacts	Environmental Impact
Impacts On Water Quality, Navigable Waterways, & Coastal Zones	
Metropolitan Planning And Air Quality Conformity	
Zoning	
Traffic Impacts	
Co Hot Spots	
Historic Resources	
Noise	
Vibration	
Acquisitions & Relocations Required	
Hazardous Materials	
Use of Public Parkland and Recreation Areas	
Impacts on Wetlands	
Impacts on ecologically-sensitive Areas And Endangered Species	
Impacts on Safety and Security	
Impacts Caused by Construction	
Environmental Impact Statement	

Incidents	Sub-Category
Project- UPA North Park and Ride at I 35W N and 95th Ave. - The action described above meets the criteria for a NEPA categorical exclusion (CE) in accordance with 23 CFR Part 771.117(d)(4).	Environmental Investigation
I-35W & 95th Ave/Phase 1 ESA for 9641 Naples St NE in Blaine	
As requested, the Minnesota Natural Heritage Information System has been queried to determine if any rare species or other significant natural features are known to occur within an approximate one-mile radius of the proposed project. Based on this query, there are rare features in the area searched (for details, see the enclosed database reports).	
We previously commented on this project on 10 December 2007 and concluded that no historic properties listed on or eligible for the National Register of Historic Places would be affected by the proposed project.	
Categorical Exclusions	
Environmental Scoping Document	

Incidents	Sub-Category
Stormwater Management study	Environmental Engineering
Warehouse site stormwater operations and maintenance plan	
Stormwater Rain Garden design	

Incidents	Sub-Category
Association Determination	Environmental Documentation
Haz Mat Report	
Leak Report	
Environmental Site Assessment	
Response Action Plan	
Categorical Exclusion	

Incidents	Sub-Category
Traffic signal revision design, using xxxx work order (xxxx desired by City of Maplewood and Ramsey County). This is a traffic mitigation required for our Maplewood ramp, but is separate from the larger construction project. The intern would probably be able to see this through construction as well.	Environmental Mitigation
VA Bus Shelter Relocation - Current location near exit and LRT tracks creates congestion. New site identified with Street Ops, need to move custom built shelter to new location	
95th Ave Ramp Wetland Mitigation Plan.	
The enclosed DRAP establishes procedures that will be used to monitor and respond to the presence of petroleum-impacted soil if it is encountered during redevelopment on the captioned site (Site).	
In response to your letter received June 10, 2011 and to the conditions under the permit issued by the Army Corps of Engineers, I am sending a replacement wetland monitoring report for the wetland created as a result of expanding the park and ride	
Construction Contingency Plans	

Incidents	Sub-Category
ADA Pads - start design of next group of pads to be constructed	Environmental Compliance
NPDES Construction Stormwater Permit application and management.	
Warehouse demolition Stormwater Pollution Prevention Plan.	
Attached for your information and records is the Closing Memorandum and EPA and MPCA Restrictive Covenants recorded against the Communications Center Site.	
This permit authorizes the applicant to grading in the south east quadrant of TH 13 and TH 77 in the city of Eagan as shown on applicant's plan sheet(s).	
Findings of Fact Statement	
Section 404 Wetland Permit	
Section 106 Programmatic Agreement	
Right-of-Way Permit	
Section 401 Water Quality Certification	
Water Appropriation Permit	
Building Permits	
Finding of on significant impact	

Incidents	Sub-Category
Community Disruption and Environmental Justice	Environmental Justice

Incidents	Sub-Category
Outreach Policy	Legitimation of Environmental Issues
Environmental Sustainability Policy	
Public Hearing Procedure	
Public Participation Procedure	
Public Involvement in the Transportation Planning Process Procedure	
Accessibility Policy	

Incidents	Sub-Category
Attention to sustainability has become a critical element to any successful business. This internship will provide valuable experience in a successful, growing and proven sustainability program. In support of Metro Transit's Sustainability Mission, learn how to collect, analyze, and report on data, solicit support and share results, see solar projects being built, and create and manage new projects.	Sustainability
Metro Transit has an established energy conservation and sustainability program. This internship will help support the agencies commitments to implement energy saving/producing projects and keep current with sustainability reporting requirements, utility usage, and goal progress.	
xxxx, xxxx is hiring interns to help out with Sustainability and should have a separate posting indicating this.	

Incidents	Sub-Category
Introduce students to the manner in which land development engineers must consider planning, environmental, and sustainability issues.	Moral Sensitivity to Sustainability
Environmental Sustainability Policy	
The internship is extended so that xxxx can continue the second year of her internship with E&F. She would continue to work on the Be the Solution program, sustainable waste project, renewable energy project, APTA Sustainability and Multi-modal Conference, water conservation projects (Rain water garden grant received for Transfer Road), grant application writing (water, storm water, electric vehicles), expansion of electric staff cars and charging stations, and reporting on our Sustainability efforts.	
Attention to sustainability has become a critical element to any successful business. This internship will provide valuable experience in a successful, growing and proven sustainability program. In support of Metro Transit's Sustainability Mission, learn how to collect, analyze, and report on data, solicit support and share results, see solar projects being built, and create and manage new projects.	
Metro Transit has an established energy conservation and sustainability program. This internship will help support the agencies commitments to implement energy saving/producing projects and keep current with sustainability reporting requirements, utility usage, and goal progress.	
The E & F Sustainability and Energy Work Group leads Metro Transit's sustainability initiatives as empowered by Thrive MSP 2040 and as required by State Statute and Executive Orders. Focusing on reducing GHG emissions and energy consumption as well waste and water management that promote and demonstrate environmental stewardship.	

Incidents	Sub-Category
The bench standards specified in Chapter 9 that the DOT ADA Regulations of 2006 adopted “shall apply where required by Chapter 2 or where referenced by a requirement in this document.” The document specify saunas and steam rooms, dressing rooms, holding cells and housing cells and courtrooms.	Specifications
I would like to provide an update on the Blue Line and Northstar benches and the ADA design regulations. During our investigation, it looks like the Department of Transportation set bench regulations in 2006. We had the actual Target Field I bench designer investigate the matter and why benches on stations built after 2006 do not meet this regulations. The designer reached out to U.S. Access Board. The Board stated that these requirements, that you and I have talked about during our meeting, do not apply on transit stations.	
Guide Specifications	
Performance specifications	

Incidents	Sub-Category
Manage annual park-and-ride survey and provide other planning/GIS technical support. (primarily Fall work)	Data Collection
Stormwater inventory	
Transit Climate Registry inventory	
Pavement condition survey	
Facility Data for B3 Database	
Traffic counts	
Passenger counts	
Bikes on Transit Survey	
Utility data	

Incidents	Sub-Category
Asset Condition assessment database	Data Management
GIS database	
Energy savings tracking	
The P&R survey has been managed annually by an intern for over 10 years; it is a regional report and data source used by many internal and external stakeholders for tracking P&R performance and decision-making related to new, closed, or improved P&R facilities.	
The landscape asset inventory is a new effort to improve the design and maintenance of landscaping at transit facilities, resulting in lower costs, better environmental stewardship, and more attractive facilities for customers and communities.	
Data management of energy and utility related information.	

Incidents	Sub-Category
Traffic detour analysis	Data Analysis
Bus service analysis	
Review parking ramp rehab study recommendations, establish preventative maintenance program and schedule for P&R ramps.	
Space needs analysis	
Utility data	
Assist with analysis of energy modeling review.	

Incidents	Sub-Category
Pedestrian Behavior	Data Aggregation
Utility data	
Stormwater inventory	
Transit Climate Registry inventory	
Pavement condition survey	
Facility Data for B3 Database	
Energy savings tracking	

Incidents	Sub-Category
The City will contract and fund the construction of solar lighting systems at up to 12 locations around the City of Minneapolis. The solar lighting systems will consist of a pole mounted PV system with a battery powering a LED light within the shelter. During construction, the Council will provide necessary construction support while the City will fund the project. At the termination of construction, the City will gift these systems and their warranties to the Council.	Collaboration
Project cost participation	
Cooperative construction projects	
Interagency agreements	

Incidents	Sub-Category
Design sidewalk connection from Naples St NE to boarding area at 95th Ave park and ride in Blaine. Would require a consultant work order and coordination with City of Blaine project to connect to sidewalk along Naples St.	Coordination
Design team coordination	
Construction activities coordination	
Public events coordination	

Incidents	Sub-Category
Project tours and Demos	Public Education
Project web site	
Op Eds/Editorials	
Customized Presentations	
Press Releases	
Project Fact Sheets/ Brochures	
Electronic Newsletter/Updates	

Incidents	Sub-Category
Media events	Publicity
Public presentation on project need and positive impact	
Community group sign-off	

Incidents	Sub-Category
This project is in an industrial area of Blaine, so little public involvement is foreseen. The public will have an opportunity to comment at a City Council meeting in October.	Public Input
Stakeholder workshop	
Project focus Groups	
Stakeholders comments	
Write-in comments	
The Metropolitan Council has a multifaceted strategy for promoting public participation in the formulation of transportation policy and implementing decisions. The strategy includes formal public participation via standing policy committees such as the Transportation Advisory Board (TAB), as well as standing advisory committees such as the Transportation Accessible Advisory Committee (TAAC).	

Incidents	Sub-Category
Public Meetings	Public Interaction
Stakeholder workshop	
Project focus Groups	
Open houses	

Incidents	Sub-Category
Good Neighbor Program	Public Partnership
Transit Joint developments	
Joint use facilities	

Incidents	Sub-Category
Nationality	Community Characteristics
Culture	
Language	
History	
Sentiment	

Incidents	Sub-Category
Contract Initiation Memo	Technical Communication
Serial memo	
Serial letters	
Submittals	
Soil reports	
Periodic Reports	

Incidents	Sub-Category
Letter to representatives	Interpersonal Communication
Letters to Cities	
Emails to contractors	
Discussions with team members	

Incidents	Sub-Category
Stakeholder meetings	Group Communication
Funding Partners briefings	
Team Meeting	

Incidents	Sub-Category
Public Focus Groups project updates	Public Communication
Media events	
Public presentation on project need and positive impact	
Public Meetings	
Stakeholder meetings	

Incidents	Sub-Category
Senior Staff briefings	Organizational Communication
FTA Project status updates	
Metropolitan Council Committees Business Items.	
City Council Meetings	
County Board Meetings	

Incidents	Sub-Category
Job diaries	Intrapersonal Communication
Notes	
Daily Journal	
Serial memo	

Incidents	Sub-Category
Tomorrow marks my last day as an intern with Metro Transit. Please divert all future correspondence regarding this project to …	Correspondence
Emails	
Job diaries	
Notes	
Daily Journal	
I have talked to _____, because ___ is out of the office until June 27. ___ stated that we would need the CIM for a sole source with a price this high. Thus, i have started working on the sole source and I have some questions with regards to both the sole source and CIM	

Incidents	Sub-Category
I had a conference call with members of the Rice Creek Watershed District (RCWD) this morning to discuss the Rule M requirements for this site.	Verbal Communication
Project Steering committee updates	
Senior Staff briefings	
FTA Project status updates	
Public Focus Groups project updates	
Metropolitan Council Committees Business Items.	
Stakeholder meetings	
Funding Partners briefings	
City Council Meetings	
County Board Meetings	

Incidents	Sub-Category
Transportation Committee Business Item Design Contract	Written Communication
Dear Secretary ______: We are happy to report that the many projects included in the Minneapolis-St. Paul Urban Partnership Agreement program are proceeding well.	
Letter to representatives	
Letters to Cities	
Emails to contractors	
Funding Partners progress reports.	
Subrecipient Notification Letter	

Incidents	Sub-Category
Emergency Declaration	Effective Communication
Sole Source Procurement Justifications	
Negotiated contracts	
Funding applications	

Incidents	Sub-Category
Communication and Outreach exhibit material	Graphical Communication
Maps	
Photos	
Animations	
Exhibits	
Charts	
Graphs	
Images	

Incidents	Sub-Category
Transportation Committee Business Item Design Contract	Presentation
Customized project Presentations	
Energy savings presentation	
City Council presentations	
Presentations to senior staff	
Public presentations	

Incidents	Sub-Category
Public hearing	Listening
Feedback sessions	
Public Meeting comments	
Work instruction	

Incidents	Sub-Category
Public presentation on project need and positive impact	Share Information
Customized project Presentations	
Energy savings presentation	
City Council presentations	
Presentations to senior staff	
Public presentations	
The Council believes that by keeping the regional planning and service-delivery process customer-focused, open and participatory, it can reflect the shared values of the metropolitan community and obtain the best available information for responsible regional decision-making.	
Senior Staff briefings	
FTA Project status updates	
Public Focus Groups project updates	
Funding Partners briefings	
Proposed ideas for team transit	
Proposed ideas for team transit	

Incidents	Sub-Category
Publication Project decision document	Ensure Transparency
Publication of Environmental Assessments	
Summary of Comments	
Publication of Agency comments and responses	
Publication of Citizen comments and responses	

Incidents	Sub-Category
Committee Consultant selection Justification	Consensus
Memorandum of Understanding	
Confirmation of Preferred Alternative	
Council Authorization	
Community group sign-off	

Incidents	Sub-Category
Cooperative agreements	Cooperation
Financing Grants	
Permitting documents	
Project funding Partnership	
Shared ownership agreement	
Maintenance and operations agreement	

Incidents	Sub-Category
Metropolitan Council Code of Ethics Policy	Work Ethical Policies
Code of ethics procedures	
Conflict of interest regarding selection of consultants	

Incidents	Sub-Category
Expected to comply with the law and professional standards	Workplace Ethical Climate
Professional codes are a consideration	
Employees are expected to follow the organization's rules and procedures	

Incidents	Sub-Category
Professional workplace training	Workplace Ethical Culture
Respectful workplace program	
Metro Transit Guiding Principles	

Incidents	Sub-Category
Design & Construction Support Services budget	Budgeting
Construction budget	
Project and Construction Management budget	
Land Acquisition budget	
Transit element budget breakdown	
Capital budget amendments	
Notice of Funding Allocation	

Incidents	Sub-Category
Cost estimate for Phase II ESA Metro Transit Park and Ride.	Cost Estimating
Engineer's Independent cost estimate	
Cost sharing estimates	
Change order cost estimates	
Professional services cost estimates	
In accordance with Metropolitan Council purchasing procedures, section 2.1.1.8 Cost and Price Analysis, "A cost or price analysis must be performed for every procurement action, including contract modifications".	

Incidents	Sub-Category
Appraisals	Value Engineering
Enhanced energy design assistance	
Alternate system part economic analysis	
Alternate economic analysis	

Incidents	Sub-Category
Appraisals	Financial Analysis
Feasibility study	
Cash flow needs analysis	
Benefit/cost analyses	

Incidents	Sub-Category
FTA 5309 & State GO Bond AVTS Subrecipient Invoice Form	Accounting
xxxx Payment Request 6_MC Approval Form	
Subrecipient Payment Approval_AVTS_UPA Funding	
xxxx Payment Request 7 _WO8	
Authorizations and Expenditures Tracking	
Draw down memo	
Subrecipient invoicing	
Financial progress reports	
Project Accounting Summary	
Certified Payrolls	
Transit element funding matrix	

Incidents	Sub-Category
xxxx and xxxx xxxx Consultants are pleased to provide you this Feasibility Study. Our several visits to the site confirmed your concerns that the existing capacity will soon exceed the 900 spaces with the additional 110 spaces to be added in 2007.	Economic Justification
Cost Justifications	
Basis of Cost	
A cost analysis concludes that it would be more cost effective to demolish the Ragstock building and to lease another building for shelters operations.	

Incidents	Sub-Category
Federal funds	Investment
Local funds	
UPA Grant $ Distribution_	
Federal Grant application	
Regional Transit Capital funds	
Chapter 152	
State Bonds	
Counties Transit Improvement Board funds	
Congestion Mitigation/Air Quality funds	

Incidents	Sub-Category
ADA compliance training	Legal Training
Historic Preservation Act, Section 106 seminar	
FTA procurement requirements	
How to buy matrix	
Terms and conditions	
Fact sheet CPV contracts	
Contract information	
Cooperative procurement ventures	
FTA Best practice manual	
Procurement tutorial	
Scope of work considerations	
Procurement processes	

Incidents	Sub-Category
City ordinance investigation	Legal Research
Examination of International building codes	
Federal regulations and best practices study	
Analysis of State Statutes	

Incidents	Sub-Category
Enclosed is a copy of the recorded Agreement and Covenant Not to Sue, Document recorded in the Office of the Registrar of Titles, Hennepin County, Minnesota.	Legal Documentation
This Agreement js entered into pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended ("CERCLA"), 42 U.S .. C § 9601, et seq . and the authority of the Attorney General of the United States to compromise and settle claims of the United States.	
Authorization of CIM for sole source procurement of a mechanical construction contract for the installation of a snowmelt heating plant system at US Bank Stadium Station Pedestrian Bridge in downtown Minneapolis.	
Enclosed for your consideration is a purchase agreement on the above property. As soon as you have reviewed it. please contact me so that I can obtain the necessary signatures for Hennepin County.	

Incidents	Sub-Category
Storm Water Permit Inspections	Legal Compliance
Notice of Proposed Construction or Alteration: Notice is required by 14 Code of Federal Regulations, part 77 pursuant to 49 U.S.C., Section 44718.	
City of Blaine will review the design and layout for building permit issuance.	
Watershed District review and permit including approval of Wetland Replacement Plan	
FAA confirmation of receipt of Notice of Proposed Construction or Alteration	
Permits	
Agreements	
Contracts	
City Resolution of Approval	

Incidents	Sub-Category
Progress reporting	Client Management
Financial Tracking	
Project closeout coordination	
Implementation plan update	
Project update meetings	

initiative	
Project execution plans	Initiative
In order to meet the requirements of Section 220500, Common Work Results for Plumbing, Paragraph 3.1, Permits and Fees, Item A, it is my opinion the Div 22 contractor needs to address all fees necessary to complete their work.	
Contract Initiation Memo	
Notice to Proceed with contracted work.	
Project Execution Plan	

Incidents	Sub-Category
Work on multiple projects	Multi-tasking
This position will assist project managers on multiple projects that vary in size and complexity and may assist on several small projects concurrently.	

Incidents	Sub-Category
Contract Initiation Memo (CIM) for US Bank Stadium Station Pedestrian Bridge Snowmelt System Heating Plant	Contract Solicitation
Invitation for bids	
Request for proposals	
Sole source proposals	
Micro-purchases	

Incidents	Sub-Category
Scoping Decision Documents	Decision making Judgement
Record of Decisions	
Participates on a team to produce decisions that balance safety, mobility, environmental impacts,	
Exercises independent engineering judgement for decision making that is appropriate for the complexity	
Independent judgment on day-to-day work and decisions.	

Incidents	Sub-Category
carrying out project and construction management.	Management
Energy conservation project management	
Design project management	
Environmental Management	

Incidents	Sub-Category
understanding of goals as related to business practices	Business Sense

Incidents	Sub-Category
As different municipalities may interpret and enforce the state plumbing code differently, it is my opinion the Div 22 contractor needed to determine, when they started the permit process, whether plan review was to be provided by the City or State; they then should have submitted plans to the City or State, with the appropriate fees, to start the permit process.	Analytical Thinking

Incidents	Sub-Category
Project milestone schedule management	Time Management
Work performance time tracker	
Construction schedule management	
Contract term of performance tracking	

Incidents	Sub-Category
Invoice log	Organization
Contract summary	
Change order summary	
Schedule of values	
Submittal log	
File management	
Chronological Correspondence	

Incidents	Sub-Category
Team member Work schedule	Team Management

Incidents	Sub-Category
Engineering and Architectural professional contracts	Contract Management
Construction contracts	
Operations and maintenance contracts	

Incidents	Sub-Category
Team Transit	Project Teams
Design teams	
Project Management Team List	
Project Technical advisory committees	
Project stakeholder group	
To assist the Public Facilities Team by working on small projects and assisting Project Managers on larger projects during the design and construction projects. Project participation will include engineering services and site inspections on Better Bus Stop projects, Park and Ride renovation projects and Transit Center renovation projects.	
Management of projects and programs that support the team objectives. The duties begin with defining the effort to be undertaken, determining the payback and often continue with data analysis to track and report progress. Specific projects for this position are as follows: lighting retrofits, lighting control audits, Air Compressor ECO implementation, energy dashboard development, sustainability documentation and guideline development.	
AutoCAD Drafter - Intern – As a Facilities Information Systems (FIS) team member, this position would draft, maintain, organize, and reproduce, floorplans. Utilizing as-Built drawings of all Metro Transit facilities as defined by the FTA Facilities Condition Assessment. The FIS team member will be responsible for converting drawings into CAD and Revit files. This team member will also locate, consolidate, and organize building systems documents into a central repository and/or library.	
The E & F Sustainability and Energy Work Group leads Metro Transit's sustainability initiatives as empowered by Thrive MSP 2040 and as required by State Statute and Executive Orders. Focusing on reducing GHG emissions and energy consumption as well waste and water management that promote and demonstrate environmental stewardship.	
Community Advisory Committee	

Incidents	Sub-Category
Pedestrians and Bicycles impacts	Transportation Impact
Traffic congestion	
Access and level of service impacts	
Parking impacts	

Incidents	Sub-Category
Utility relocation	Utility Impact
Utility easements	

Incidents	Sub-Category
Utility impacts	Land Development Impact
Drainage impacts	
Traffic impacts	
Construction impacts	
Environmental Impacts	

Incidents	Sub-Category
Effective site development	Responsible Site Development
Responsible Site development	
Site Planning/development	
Site development permitting	
Introduce students to the manner in which land development engineers must consider planning, environmental, and sustainability issues.	
Site layout	
Site preparation	
The following factors are to be used to determine if a site is acceptable for the intended Metro Transit use.	

Incidents	Sub-Category
Grant closeout	Project success
Construction closeout	
Grand opening	
Certificate of occupation	
Closeout checklist	
As-built drawings	

Incidents	Sub-Category
understanding of goals as related to business practices	Goals-Strategy Alignment
Procedures that aims at integrating the management of resources to meet project needs.	
Support regional economic competitiveness	
Advance equity by improving multimodal access to opportunity for all	
Support a 21st century transportation system through increased ridership and revenues.	

Incidents	Sub-Category
Project Budget deficit	Impeding Factors
Business opposition	
Level of potential Impact	
Preferred Alternative	

Incidents	Sub-Category
Uncertainty	Unstructured Problems
Community norms and values	
Decision-making process	

Incidents	Sub-Category
Key strategies are encouraging more public awareness of transportation issues and soliciting stronger community and customer involvement in transit planning and facility siting discussions.	Guiding Principles
This facet of ongoing public involvement in the transportation planning process provides the opportunity for continuing citizen involvement through advisory bodies that review and recommend policy direction to the Metropolitan Council on a variety of transportation policy issues. The standing citizen advisory committees related to transportation include the Transportation Advisory Board and Transit Accessible Advisory Committee. The TAB consists of local elected officials, citizens, and representatives of governmental agencies with transportation responsibilities.	
The Metropolitan Council is committed to being a responsive and participatory agency for regional decision-making. The Council believes that by keeping the regional planning and service-delivery process customer-focused, open and participatory, it can reflect the shared values of the metropolitan community and obtain the best available information for responsible regional decision-making.	
Safety	
Environmental responsibility	
Innovation	
Teamwork	
Community Orientation	
Financial Responsibility	

Appendix B

PROJECTS DESCRIPTIONS

Project Number	Project Name	Project Description
1	O&M Garage Expansion	To design and construct an expansion to the existing Operations and Maintenance (O&M) facility. The O&M Facility needs to be expanded to accommodate the new light rail vehicles (LRV) that will be purchased for the Hiawatha 3-car train program, as well as the future Central Corridor line.
2	I-35W/95 Park-&-Ride	As part of the Urban Partnership Agreement (UPA), a parking structure is proposed to be constructed north of the existing park and ride site at I-35W and 95th Avenue in Blaine, MN. This parking facility will consist of about 1500 parking spaces – increasing the capacity of the existing park and ride by approximately 500 (spaces in the surface lot will be removed to rebuild the boulevard along Naples Street). Wetland Mitigation and removal of one billboard will be completed in conjunction with the facility construction. Construction of this parking ramp must be complete by September of 2009.
3	Metro Transit Police Department	The project is the design and construction of a new Metro Transit Police Department Headquarters. The new facility is proposed to be located on the Heywood Campus (on property owned by the Council) to the east of the existing Metro Transit Administration Building, adjacent to Sixth Avenue North. The original project consisted of designing and constructing approximately 40,000 gross sq. ft. of office/storage space with secure underground parking facilities for approximately 80 to 100 police vehicles. The project has now been modified to include the following: The building will contain approximately 62,000 gross sf of office/storage space 1) secure, ground level parking facilities for approximately 50 to 70 police vehicles; 2) approximately 5,000 gross sq. ft. additional space for additional police needs; 3) approximately 8,000 gross sq. ft. of Metro Transit office space and shared facilities space; 4) renovation of approximately 6,000 gross sq. ft. of FTH Admin Building (first floor); 5) inclusion of approximately 2,000 gross sq. ft. for a clinic; and 6) relocation of underground utilities, widening of the bus lane, and construction of a retaining wall.. Attached Figure 1 shows the general location of the MTPD Headquarters in relation to the FTH Administration Building and the FTH Garage.
4	Ramsey Station Snow Melt	Design heat source system for platform melting at Ramsey Station (this will only occur if system found feasible and if funding partners agree to continue with it – feasibility study done in late April).

5	I-35E and Cty E Park-&-Ride	The I-35E & Co Rd E Park-and-Ride will be a 300-space surface parking facility with service to Downtown St. Paul. The project is programmed for land acquisition in 2011, design and construction in 2012. Funding sources include a Chapter 152 award (State Trunk Highway Bonds) , FTA 5307 funds, and RTC. Land acquisition for this park-and-ride facility will be somewhat complex because we will need to work with two different property owners
6	I-35E and Cty 14 Park-&-Ride	The proposed project involves the planning, design and construction of a new 300-space surface park-and-ride facility along the I-35E north corridor at County Road 14 in Lino Lakes. The proposed facilities will provide efficient express bus service to Downtown St. Paul and will serve park-and-ride users residing primarily in the Northeast Metro. Express bus service to and from the new facility will be provided by restructuring service from smaller, leased park-and-ride lots along the I-35E corridor. Currently, express bus service to St. Paul requires multiple stops at four facilities and relatively inefficient routing along Centerville Road to reach the facilities. Constructing larger facilities will enable Metro Transit to concentrate and streamline express bus service in locations with direct access to the freeway.
7	METRO Orange Line	METRO Orange Line is a 17-mile planned highway BRT line between Minneapolis, Richfield, Bloomington, and Burnsville (see page 9). All-day, frequent, bidirectional service will complement local and express bus routes in the I-35W corridor, providing competitive running times for station-to-station trips and a new option for reverse-commute markets. Both BRT and express riders will benefit from stations, runningway, technology, and service improvements.
8	Better Bus Stop	Metro Transit's community engagement goal is to engage the people and communities who are traditionally under-represented in transit decision-making processes, and are most impacted by these decisions, to ensure that they are engaged and involved in this work. We will engage the community in discussions focusing on equity and policy surrounding the investment of resources at the bus stop level. This project will improve bus stops and shelters focusing on neighborhoods with concentrations of poverty and people of color in Minneapolis, St. Paul, Brooklyn Park, Brooklyn Center and Richfield. These improvements will enhance customers' access to jobs, education and services. These improvements include installing new bus shelters, placing lights in new and existing shelters wherever possible, installing heaters at some shelters, making pedestrian and ADA improvements around some shelters, installing enhanced transit information along routes and installing community signage.
9	American Boulevard and Platform	A new HLRT station called the American Boulevard Station, located at the intersection of 34th Avenue and American Boulevard (80th Street) in Bloomington, Minnesota. An extension to platforms at ten of the existing HLRT stations to allow for 3-car trains.

10	Downtown East Pedestrian Bridge	Due to the large pedestrian volumes and the number and frequency of trains post event, the pedestrian bridge near the 4th and Chicago intersection is required to ensure the ability to move event attendees safely from the stadium across the LRT tracks to their destinations and provide for safe and reliable LRT operations to accommodate the projected 42 percent mode split. Metro Transit (COUNCIL) intends to construct a pedestrian bridge to address and eliminate street level pedestrian crossing of the LRT tracks at the 4th Street and Chicago Avenue intersection during events at the Minnesota Multipurpose Stadium.	
11	Heywood Facility	Engineering and Facilities is continuing ahead with the design of the New Minneapolis Bus Garage and additional resources are needed to help coordinate/manage the design between internal and external stakeholders and reviewers. The Heywood bus garage (Heywood campus) also has an extensive renovation program that is being developed than needs additional assistance. This internship will help us to manage a major upgrade at the Heywood Campus, in particular, developing and implementing plans for maintenance and transportation improvements, as well as manage new smaller projects that come up during the summer.	
12	Mall of America Platform	The proposed project involves the redesign of the Mall of America Transit Station in Bloomington, Minnesota. The project is located along 24th Avenue in the East Parking Ramp at the Mall of America. The project also includes constructing: ·New façade on the 24th Avenue Elevation · New mall entry · New busway · New transit station · Removal of existing Transit Station · Reconfiguration of a gate and parking	
13	Metro Transit Public Art Policy	This project will create a Public Art policy that defines the goals and funding for Metro Transit's public art program and a Public Art Procedures document that guides planning, implementation, and ongoing operational needs of Metro Transit's public art program.	
14	Government Center Station Inter-Track Fence	Metro Transit (the Council) intends to install an inter-track fence at the Government Center LRT Station. The work on this project provides design services for the preparation and recommendation of fence designs that have minimal visual impact, meet code requirements, and require minimal maintenance. The Consultant will be responsible for preparing conceptual designs that meet Minneapolis Heritage Preservation Commission (HPC) and Community Planning and Economic Development (CPED) requirements. The Consultant will also be responsible for presenting the concept designs to the Council, HPC and CPED.	