A Critical Examination of the Construct Validity of the TTI Performance DNA^{TM} Survey for the Purpose of Differentiating the Entrepreneurially-Minded Engineer

by

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Abstract

The United States needs workers with more than technical skills to meet the demands of global competition; more specifically, a new breed of engineer is necessary, one who possesses leadership skills and business acumen in addition to the technical engineering skills. One Midwestern Foundation has recognized this challenge and is working with engineering universities to enhance programs to create entrepreneurially-minded engineers (EMEs). To this end, the Target Training International, Ltd. (TTI) Performance DNA™ survey has been developed to measure the behaviors, values, and professional skills of these EMEs. Currently, the Foundation has collected data using this survey with engineering students and entrepreneurs; this research has examined the difference between practicing engineers and engineers who have attained a leadership role, or an EME.

This research examined the construct validity of the TTI survey and its ability to distinguish between engineers and entrepreneurially-minded engineers (EMEs). The survey was administered to engineers (by degree) working in the industry and distinguished the EMEs by self-reporting of their job title. Those in a leadership role or an entrepreneur were categorized as EMEs. The survey was able to distinguish between engineers and EMEs in both behavior and mastery of professional skills. The statistical analysis determined a significant difference between the two groups, separate from other demographic factors such as time on the job and graduate degree attainment. Ultimately, the results of this research will help engineering institutions create a better engineer for the purpose of leading innovation and creating economic strength in the United States. Recommendations for future research include comparing these data to those of other groups of practitioners in other countries, including student groups, and conducting longitudinal studies of students as they progress from freshmen to seniors.

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Chapter 1: Introduction and Background

This thesis will present a descriptive study to examine the construct validity of a measurement assessment survey to define the difference between engineers and entrepreneurially-minded engineers. The study will use statistical methods to provide a quantitative analysis of survey results from practicing engineers. This chapter will provide the introduction and basis for the study significance, research questions, and limitations. The following chapter will show research into applicable literature, and methodology will be shown in Chapter 3. Chapter 4 will show the results of the methods used, and finally conclusions and recommendations will be presented in the interest of further research.

Background

The United States has enjoyed economic strength and innovation leadership throughout the twentieth century. The American way of life has been a global standard for freedom and independence, but especially for the opportunity for individuals to live "the American Dream," which was rooted in the ability to work hard and enjoy the economic rewards. However, the twenty-first century has moved from into the post-industrial economy to an economy "distinguished by jobs that require technical skills..." (Smith-Nightingale, 2010, p. 680). "We [America] have led the world for decades, and we continue to do so in many research fields today. But the world is changing rapidly, and our advantages are no longer unique" (The National Academy of Sciences, The National Academy of Engineering, and The Institute of Medicine, 2006, p. 8). The United States is losing its economic dominance, and the national economy must change from historical models. According to Pisano, "Only by rejuvenating its innovative capabilities can America return to a path of sustainable growth" (2009, p. 13).

Mukoyama states, “New technologies are the engines for economic growth” (2004, p. 451). The importance of innovation is a hallmark of American economic strength. The United States’ economy has been strong due to innovation and entrepreneurship, from the agricultural beginnings to the industrial revolution and onto the post-industrial economy based on technology and service (Smith-Nightingale, 2010). The economy relies on creating and improving existing products; individuals and businesses lead innovation. Businesses and entrepreneurs who innovate create economic growth for the overall economy. This was hypothesized by economist Joseph Schumpeter (1935) in his seminal research that recognized economic cycles and how innovation and entrepreneurship upset equilibrium and caused economic change. He is recognized for his definition of entrepreneurship relative to economic value (Bull & Willard, 1993). Wennekers and Thurik (1999) studied and confirmed the relationship between entrepreneurship and economic growth. In 2005, an empirical study from vanStel, Carree, and Thurik showed a direct link between entreprenreurship activity and economic growth (using GDP growth) in higher economically developed countries (measured by GDP per capita). In highly developed countries, the level of entrepreneurship has a positive influence on economic growth. Lentz and Mortensen (2008) also created an empirical model to show that firm innovation leads to economic reward using data from Danish firms from 1992 – 1997.

Further illustration of this relationship was presented by John Haltiwanger, who suggests that the recent economic downturn in the United States is due to the lack of new business start-up firms (Haltiwanger, 2012). Economies are dynamic in that businesses are constantly entering and exiting. However, normal churn will result in a steady-state model unless there are more new businesses created to drive economic growth. Other economists agree that smaller firms will assist in the economic growth. Wadhwa argues, “To solve its big economic problems, the United

States needs to think small. It is a well-worn observation that technical innovation leads to economic growth" (2012, p. 1). Weber and Rohracher argue that policy changes are needed on a more fundamental level to encourage innovation, and "more is needed than individual product or process innovations at firm level, but comprehensive system innovations" (2012, p. 1037). Policies are needed to encourage innovation and drive growth. Every part of the economy, from governmental policies to tax laws and labor availability, should focus on growth.

America's chance to regain economic strength lies, in large part, in the technical abilities of its people. The science and technology community largely agree that human talent, especially in science and engineering, is becoming ever more essential to national well-being (Wadhwa, 2009). It is recognized that the future will need technologically-savvy practitioners. Wirasinghe states, "The 21st century will see engineers assume a more prominent role, notably as innovators and technological guardians of the knowledge-based society, but also in international commerce and leadership of successful nations" (2000, p. 1). The need for skilled engineers as the future innovators and leaders for the country's economic power and growth is clear. Firms recognize the benefit of creating an organizational learning environment for the encouragement of their technical staff to innovate (García-Morales, 2011). Their study showed a direct correlation between a firm's ability for technical innovation and the use of internal communication and organizational learning. Therefore, engineers and technical skilled individuals need to understand the dynamics of communication in the knowledge-based society. Dubina, Carayannis, and Campbell (2012) present the interrelationships among knowledge, creativity, and innovation as both economic drivers and effects. They argue that too much innovation may actually result in an economic downturn; however, ongoing innovation and creative ideas are necessary for an overall healthy economy.

As the economy model changes with technology, it follows that education must change as well. According to Clouse, "The world is unstable and uncertain, but yet most of our formal education systems teach students how to work and live in a stable and structured organized world" (2007, p. 2). Educational institutions that teach twentieth century ideas are no longer adequate for the 21st century future and beyond. Continuous learning is necessary since no one can forecast the topics that engineers will be expected to learn ten years from now (Tribus, 2005). Therefore, education reform and learning methodology must be enhanced and rewritten to meet future demands, especially in the technical fields like engineering.

One foundation recognized this need for change and has taken action by developing the Kern Entrepreneurship Education Network (KEEN). This is a collaborative group of more than twenty private engineering colleges whose goal is "to increase the quantity and quality of U. S. engineering talent" (Kern Family Foundation, 2011). They have developed a model of the type of engineer necessary for the future: the entrepreneurially-minded engineer (EME). This is to not only shape the future but to address the immediate need. Silva, Henriques, & Carvalho posit that "there is a significant gap between university and industry regarding the attributes of a novice engineer" (2009, p. 64). The American Society for Engineering Education supports this idea, stating, "Future engineers must possess a broad set of skills, abilities and attitudes reflective of the multi-faceted, global challenges they will face" (2012, p. 48). The KEEN schools are working together to fill this gap by developing curriculum and using different pedagogy to create more entrepreneurially-minded engineers. These EMEs are based on the model in Figure 1 (Kriewall & Mekemson, 2010):

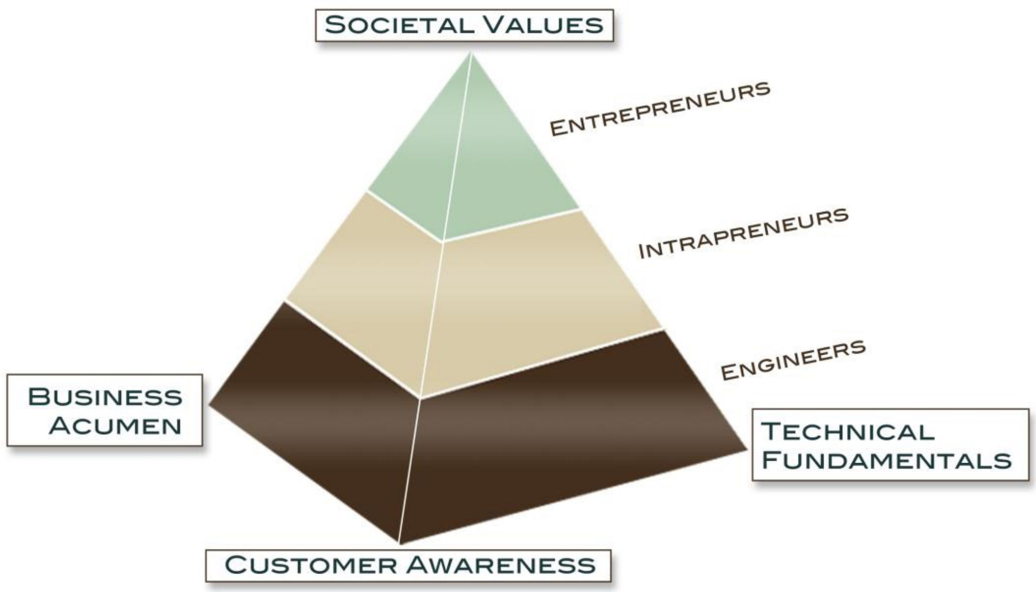


Figure 1. The KEEN Pyramid

The EME is not necessarily an engineer who starts a business but rather one who has the skills and talent that enable those types of activities. The KEEN mission is to influence all types of engineers, moving up the pyramid. The skills that the EME possesses are grouped by the four interdisciplinary corners of business acumen, customer awareness, technical fundamentals, and societal values. With skills that address each of these concerns, these engineers can become the innovators and business leaders of the future (Kriewall & Mekemson, 2010). EMEs are engineers who can not only answer questions by using strong problem-solving skills but who can also ask the right questions and develop new ideas for problems that have not been discovered. For example, a typical engineer can solve a problem presented to him or her. The EME will be able to not only answer the question but also come up with more creative solutions and more questions.

Statement of Problem

Currently the specific types of measurable behaviors, values, and professional skills that entrepreneurially-minded engineers (EMEs) possess are hypothesized in the Target Training International, Ltd. (TTI) Performance DNA^{TM} survey; however, these behaviors, values, and professional skills have not been validated by using data to differentiate between EMEs and other engineers, non-EMEs.

The problem is to validate if the TTI Performance DNA^{TM} survey instrument can differentiate between EMEs and non-EME or if those differences are simply an outcome of other indicators, such as time on the job. This research is a critical examination of this measurement tool and its effectiveness in highlighting differences in engineers and engineering leaders, or entrepreneurially-minded engineers. A successful measurement tool will provide direction for those organizations interested in creating EMEs, specifically engineering educators. If the EMEs can be differentiated from the non-EMEs, then a unique profile can be created using the behaviors, values, and skills defined by the assessment survey.

Purpose of the Study

The purpose of this research is to determine if the TTI Performance DNA^{TM} assessment is a valid instrument to quantitatively define the behaviors, values, and professional skills of practicing EMEs, compare the EME to other engineers (defined as “non-EMEs”), and if so, discuss how these profiles can be used to measure educational programs designed to create EMEs. It is necessary to determine the construct validity of the TTI Performance DNA^{TM} survey for the purpose of differentiating the EME to the non-EME. This research is viewed as a critical need for the KEEN schools. The schools are measuring the engineering students but have no comparator information. That is, they have profiles of engineering students; however, they have no data on practicing EMEs. This study will provide those comparators and show the validity of using the behaviors, values, and professional skills as measured by the TTI Performance DNA™ survey.

This research will provide the “voice” of industry and practicing engineers in order to direct educational changes in specific directions. For example, if engineering students score low in leadership as a professional skill and EMEs score high, educators can work toward better leadership development initiatives. However, if both students and EMEs score low on mentoring skills, it is not necessary to develop better mentoring practices. These definitions will also contribute to the general body of knowledge for engineering education and changes in pedagogy that are underway to meet future demands. This will contribute to creating a better engineer.

Significance of the Study

This research is significant because it offers insight into industry practitioners, while other current studies primarily reflect engineering students. There are studies that gather opinions of industry leaders; however, these data are limited and typically result from small scale qualitative interviews and opinions. The data for engineering practitioners and engineering leadership are not currently understood or available. This study will close the gap in understanding the skill set of practicing engineers and engineers in a leadership role and determining whether there is a difference in the skill set. Even within the KEEN network itself, these profiles do not exist, as prior and current studies have measured only students and entrepreneurs.

Table 1

KEEN Research Data

Students	Engineers	Engineering Leaders	Entrepreneurs
YES	NO	NO	YES

These data will provide a baseline measurement to be used as a comparator between the other groups and determine patterns. These comparisons will also be used to provide direction to the educators in determining progress of creating EMEs. For example, engineering leaders may show higher professional skills in the area of flexibility. If students show low levels of flexibility, educators can infuse more activity into the curriculum to enhance the students' learning around flexibility. In addition to the survey outputs defining behaviors, values, and professional skills, this research will include demographic data as a comparison. For example, is a specific characteristic changing with time on the job, or is it due to an individual's behavior? These demographic data are not available with any of the existing student or entrepreneur data sets. The demographic data will provide insight that is currently not included in other research data.

Research Questions

This research is designed to answer the following questions:

1. Is there a difference between the behaviors, values, and professional skills of entrepreneurially-minded engineers (EME) and engineers (non-EME), or are these groups different due to other factors, such as time on the job?
2. Is the TTI Performance DNA™ assessment survey a valid tool to determine these differences?

3. If there is a difference, what is the profile of an EME and how does that compare to the non-EME?
4. How can these data be used to determine differences in various groups of interest such as students, engineers, or entrepreneurs?

The TTI Performance DNA™ assessment survey is the tool that the KEEN schools are using to measure the performance of their students. However, it is not known whether this tool is effective in differentiating the EME or non-EME. For example, there are data captured from the students at the KEEN schools that reflect their various behaviors, values, and skills as measured by the survey. Yet it is not known if the survey can differentiate between EMEs and non-EMEs. This research will provide the quantitative analysis to answer that question, as measured by the TTI survey.

The TTI Performance DNA™ survey was developed as a performance measurement tool and combines three distinct assessment areas: behaviors, values, and professional skills. Behaviors or behavior style is measured using the DISC assessment tool (Bonnstetter & Suiter, 2011). This survey is similar to other psychological behavior assessments such as the Myers-Briggs Personality Inventory based on Carl Jung's original work in 1921. The values and professional skills are measured and presented in numeric outcomes discussed below. The TTI survey is an electronically-delivered assessment that asks participants various questions about their preferences and performance. Target Training International, Ltd., then takes the answers to those questions and develops a resulting profile of the participant in terms of their behavior style, values, and mastery of professional skills. The outcome is presented to the participant in a comprehensive report that defines their behaviors, values, and skills in terms of a numeric output. This output includes a discussion about how to use the assessment for personal improvement. Another use of the survey is a tool for team cohesiveness. For example, each member of a working team takes the assessment. By sharing their results with each other, individuals can see other's profiles and determine how best to work with them. One team member may be good with leadership and management skills, which would suggest they lead the team. Another participant may be good at organizational skills, so he or she can be the program manager of the team and keep everyone on task. By maximizing individual strengths, the team will perform better.

The current research conducted primarily by the KEEN schools is student-centered. Specifically, student populations at the KEEN universities have taken the TTI Performance DNA™ assessment, and data have been collected (Fry, Jordan, Dougherty, Rayess, Singh, & Bloemer, 2012). However, there are no data to use as a comparison. For example, if students score high in the professional skill of problem solving, does that resemble the profile of an EME or a non-EME? Further, practitioner data can be sorted based on whether they fit the profile of an EME or non-EME. As more data are collected, they can be segregated into the two groups to allow for stronger conclusions to this and subsequent research.

Personality surveys rely on self-reporting. Validity is important to understanding whether the outcome of the survey is reliable; that is, does it measure what it is supposed to measure? This research will use results from a nominated sample of practitioner engineers to determine whether the survey results are different between two groups operationally defined as EMEs and non-EMEs, using a self-reporting classification of job title. Confidentiality was assured, and this should help participants answer questions honestly. The data were used for this research and other studies in aggregate, not examining individual reports. Those individual reports were for the use of the participant only.

The hypotheses tested to address this research are the following:

1. Test One:

H_0: There is no significant difference between the EME and non-EME groups in terms of behaviors, values, or skills.

H_1: There is a difference between the EME and non-EME groups in terms of behaviors, values, and skills.

2. Test Two:

H_0: There is no significant difference between the EME and non-EME groups in terms of time on the job or graduate degree attainment.

H_1: There is a difference between the EME and non-EME groups in terms of time on the job or graduate degree attainment.

3. Test Three:

If a difference is found between the EME and non-EME groups, define the specific behaviors, values, or skills that differentiate the EME and non-EME groups in terms of which groups are statistically significantly different.

Conceptual Framework for the Study

The conceptual framework for defining the characteristics of the EME is based on social science and measuring human behaviors. TTI Performance Systems, Ltd., is a company with more than 25 years of experience in providing assessments for measuring human characteristics (TTI, Ltd., 2011). They have developed the TTI Performance DNA™, which has been used by KEEN to provide the operational definitions of engineering students in their programs. The TTI Performance DNA™ survey is composed of three sections: behaviors, values, and professional skills. Survey data from a recent study of 1,717 people resulted in a Cronbach's alpha of .747, which is considered reliable (Pistrui, Layer & Dietrich, 2012).

The behaviors section is based on the DISC assessment, which represents Dominance, Influence, Steadiness, or Compliance and is defined in Figure 2 (Bonnstetter & Suiter, 2010):

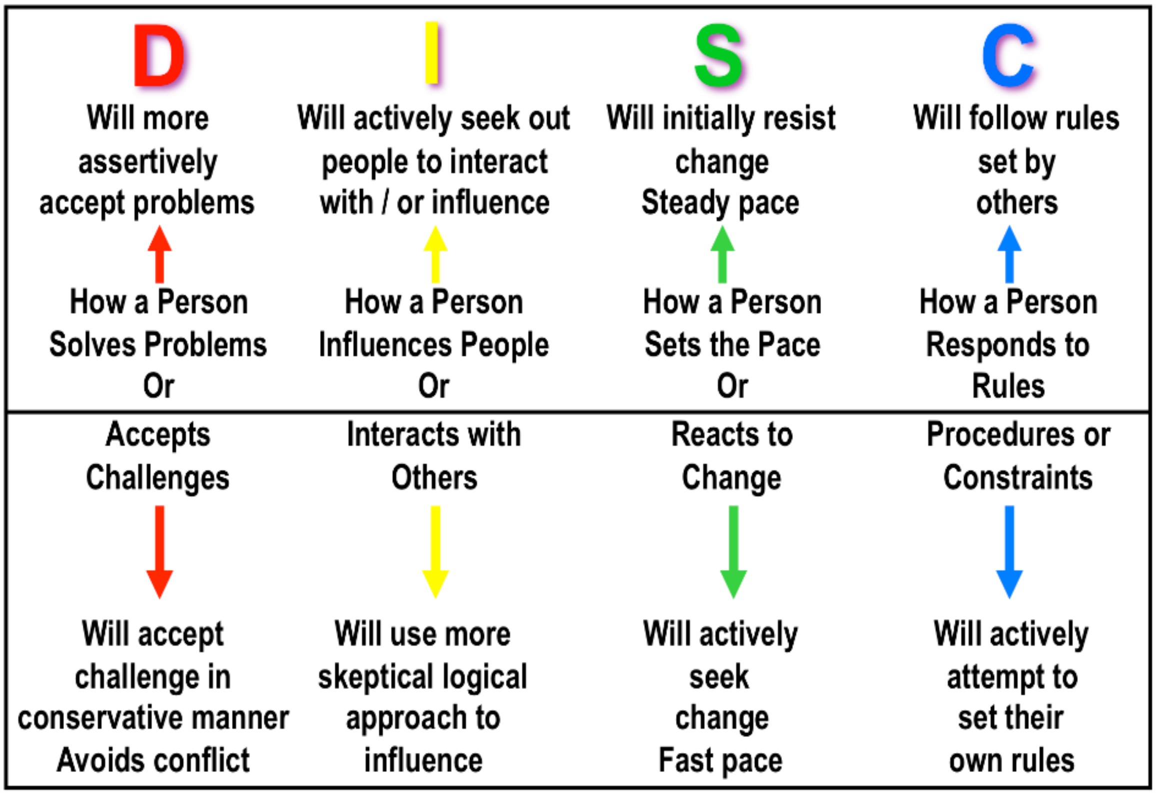


Figure 2. DISC Definition

The DISC model is based on the original work of William M. Marston, who wrote *Emotions of Normal People* in 1928, and is credited originally to John Geier as a measure of psychological behavior (2011). The model categorizes personal behavior in four dimensions: Dominance, Influence, Steadiness, and Compliance. These behavior styles help individuals understand how they solve problems, influence people, react to change, and respond to rules. This provides people with a self-assessment tool for the purpose of self-reflection and understanding how they interact with others in a relationship. For example, a person who scores high on the dominance scale may appear to be pushy or impatient. Yet this is a result of their personality behavior as they are direct, to the point, and results-oriented.

In Marsten's book, he describes a relationship between a person's responses to stimuli and refers to these actions as "motor self" and "motor stimuli" (p. 104). The combination of each relationship between the self and stimuli are described in terms of DISC; Marsten's descriptions are:

D: Dominance

I: Inducement (Influence)

S: Submission (Steadiness)

C: Compliance

Each of these four emotions is "formed by conjunctions of various types between the motor self and transient motor stimuli" (p. 107). For example, the dominance emotion is a "reaction of the motor self which is antagonistic to a motor stimulus and an increase in strength" (p. 106). Further, the emotions are regulated based on stimuli and can be adjusted, such as the volume knob on a radio. Marsten's work was the results of years of psychological study in people, animals, and physical or natural phenomena. He drew parallels among the three to strengthen his theory on human behavior. For example, he described the differences between dominance and compliance using an analogy of a river flowing over a particular path (compliance) or creating a new one (dominance). It is also evident from his research that a person does exhibit each of these emotions at one time or another; there is the ability in each person to be dominant at one time and submissive in another.

Bonnstetter (2011) further describes how people have both a natural behavior and adapted behavior; that is, people may adapt different behavior styles to each situation. For example, a person may exhibit characteristics of a highly Dominance behavior at work but not at home. This is the result of persons adapting to their environment. For the purpose of this research, only the natural behavior style will be used in the comparison assessment. The natural behavior style better reflects who a person is and his or her behaviors, not the behaviors a person feels are necessary to interact on the job or perform better. Other assessments on adapted behavior or a comparison between the natural and adapted styles can be the subject of further research.

The second section of the TTI Performance DNA™ Assessment is composed of six values. A person's values are what motivate him or her, and they are the reason a person has a particular attitude that will drive his or her behavior. The assessment describes the relative importance of six values (Bonnstetter, Bonnstetter, & Preston, 2010):

Table 2

Six Values Definition

Aesthetic	A drive for beauty, form and harmony in objects, nature or experiences
Traditional	A drive for an orderly, well established, unified structure for living
Social	A selfless drive to help others
Utilitarian	A drive for a practical return on time or money spent to accumulate wealth and what is useful
Theoretical	A drive for knowledge, discovery and continuous learning
Individualistic	A drive for personal power, influence and control over surroundings

Each person will have each of these values to some degree; the survey defines them in order of importance. A person with a high result of a social value will be motivated to help others over the drive for money, and this person will typically rather volunteer his or her time instead of continually striving to make more money. A typical artist or person who appreciates music or other art forms would show a high result on the aesthetic value.

These values are based on Spranger's original research described in his book *Types of Men* (1928). His study recognized that individuals were the product of their cultural environment and they made decisions based on certain values. "Whatever is objectively valuable in a culture must be thought of as the fulfillment of norms of evaluation, as the results of laws of evaluation which confront the individual as demands unless he obeys them of his own accord" (p. 14). He describes six attitudes as basic types of individuality:

- Theoretic
- Economic
- Aesthetic
- Social
- Political
- Religious

These six are always part of a person's decisions; however, one or two tend to be dominant in a given situation. Spranger describes an example in which a person is given a ring (p. 86). "This ring is shiny" shows an aesthetic value. "This ring is gold" shows a theoretic value. "Gold is rare" shows the economic value, and "my mother gave it to me" shows the significance of the object. The combination of these values shows the significance of one act, which is the summary of a person's life experiences and the culture they were a part of.

The third section of the assessment defines 23 professional skills. These are described in the Table 3 (Bonnstetter & Suiter, 2010).

Table 3

Professional Skills Definition

Leadership	Achieving extraordinary business results through people
Goal Orientation	Energetically focusing on meeting a goal, mission or objective
Presenting	Communicating effectively to groups
Employee Development Coaching	Facilitating and supporting the professional growth of others
Interpersonal Skills	Effectively communicating, building rapport and relating well to all kinds of people
Persuasion	Convincing others to change the way they think, believe or behave
Personal Effectiveness	Demonstrating initiative, self-confidence, resiliency and a willingness to take responsibility for personal actions
Management	Achieving extraordinary results through effective management of resources, systems and processes
Flexibility	Agility in adapting to change
Creativity Innovation	Adapting traditional or devising new approaches, concepts, methods, models, designs, processes, technologies and/or systems
Decision Making	Utilizing effective processes to make decisions
Negotiation	Facilitating agreements between two or more parties
Conflict Management	Addressing and resolving conflict constructively
Futuristic Thinking	Imagining, envisioning or projecting and/or predicting what has not yet been realized
Customer Service	Anticipating, meeting and/or exceeding customer needs, wants and expectations
Continuous Learning	Taking initiative in learning and implementing new concepts, technologies and/or methods
Analytical Problem Solving	Anticipating, analyzing, diagnosing and resolving problems
Teamwork	Working effectively and productively with others
Written Communication	Writing clearly, succinctly and understandably
Diplomacy	Effectively handling difficult or sensitive issues by utilizing tact, diplomacy and an understanding of organizational culture, climate and/or politics
Self-Management	Demonstrating self-control and an ability to manage time and priorities
Planning and Organizing	Utilizing logical, systematic and orderly procedures to meet objectives
Empathy	Identifying with others and caring about others

The professional skills are measured with respect to mastery. The mastery defines a person's major strengths (Target Training International, Ltd., 2011). For example, a person who exhibits mastery in Empathy exemplifies the following in their performance:

- Demonstrates genuine concern for others
- Respects and values people
- Perceives and is sensitive to the emotions people experience
- Expends considerable effort to understand the real needs, concerns, and feelings of others
- Advocates for the interests, needs, and wants of others
- Demonstrates cross-cultural sensitivity and understanding
- Takes personal and/or professional risks for the sake of others.

A person's experience in various areas will result in mastery of some but not all 23 skills. The assessment is meant to highlight the skills in which an individual shows a level of mastery and also those areas in which he or she can improve. Typically these skills are associated with job performance. This type of assessment is useful to those who want to understand how well they perform with specific skills that are required for certain jobs. For example, if a person is considering an administrative assistant position, he or she should have some mastery of planning and organizing skills, not necessarily leadership. Each of the 23 professional skills has associated descriptions, and these are detailed in a participant's individual report (Target Training International, Ltd., 2011). This detail provides additional understanding of mastery as defined by each of the skills.

These three sections form the basis of the definition of a person's characteristics. Each of the four DISC results, six values, and 23 professional skills will have a numeric result based on survey questions. The specific combination of questions and responses are translated into the numeric results, and this procedure is a proprietary process developed by Target Training International, Ltd. These outcomes will be aggregated and analyzed to form the descriptive definition of an EME and compared to a non-EME. If these two groups are significantly different, then the specific differences will define how an EME has a unique set of behaviors, values, and skills.

The TTI survey takes approximately 20-30 minutes to complete, times will vary based on how quickly the respondent answers each question. As with any self-reporting survey, respondents should respond as the first thought that comes to mind.

The first section of the survey is used to determine the DISC behaviors. For this section, respondents are instructed to rank each phrase that is most like them. Each question has four phrases, and respondents number the phrases from one to four, one being the most like themselves. For example, one question asks participants to rank the following:

- Enthusiastic
- Contented, satisfied
- Positive, confident
- Peaceful, tranquil.

Another example of a question of four is:

- Logical
- Obedient, will do as told, dutiful
- Unconquerable, determined
- Playful, frisky, full of fun.

There are a total of 24 questions where participants respond by ranking the four characteristics. The combination of the answers to these questions provides the basis for the DISC behaviors.

The second section of the TTI survey evaluates a person's motivation values. In this section there are twelve items, each with six choices. As with the behavior section, the participant is asked to rank each of the six responses. For example, two questions are listed below:

- My favorite subjects to study:
  - Math/Science
  - Political Science
  - Ethics/Principles
  - Fine Arts
  - Financial Planning
  - Humanitarianism
- My personal goals:
  - Helping others
  - Elected official
  - Economic freedom
  - Discovering new technology
  - Artistic expression
  - Sharing my beliefs.

These twelve questions are evaluated and provide the basis for the six categories of motivating values.

The final section of the TTI survey is to assess the participant's mastery of professional skills. There are three parts to this section. The first asks the participants to check each of the word-sets that have been used to describe them in the work place. These include:

- Mentor/facilitator
- Problem solver/Inquisitive
- Writer/Editor
- Caring/Compassionate
- Negotiator/Mediator.

There are 24 such word-sets that the participants can select. The second part of the skills section is a list of 42 statements, and participants are asked to rank their agreement to the statement. For example,

- I know what I want and I usually get it
- I prefer structure in my work
- I prefer to be evaluated on my results rather than my methods
- I rely on my instincts to solve problems.

The participants rank each statement on a six-point scale to indicate how strongly they agree on the statement. They are also given the choice of "no opinion."

The final part of the skills assessment section is a total of 50 statements. Participants are asked to select a rank from one to six as to how accurately each statement describes their record of accomplishments, activities, and results. For example,

- I spend time in libraries, bookstores and researching on the Internet

- I have been recognized for achieving results when others couldn't
- I have played a key role in negotiating significant contracts or agreements
- My ability to get along with people has been a key to my greatest accomplishments.

The ranks to these statements are compiled along with the other two parts of this section to conclude a person's mastery of the 23 professional skills.

Limitations and Delimitations

The research conclusions will reflect the demographics collected during the study. The study asks participants to indicate their job title, the region of the country they live and work in, whether they have attained a graduate degree, and how long they have worked at their job. The intent is to define a national profile; however, not all areas of the nation may be represented. The demographic data will be analyzed in order to draw appropriate conclusions about the applicability of the study results to represent a national profile. The collected data will reveal whether a national profile is appropriate by showing how many participants are from each region of the country and then determining if there is a difference between the responses in each region. If there is not, then it will be reasonable to assume the profile is appropriate to use as representative of the entire country.

The TTI Performance DNA™ Assessment survey is intended to reflect a person's values, behaviors, and professional skills. However, there is some debate as to whether these specific characteristics are those that can differentiate EMEs. Even among the KEEN collaborators, different tools have been used to measure student profiles. The TTI assessment tool is not the only measurement method available to assess profiles; however, it is the selected method for this research and most of the current KEEN school student data. Therefore, it is important to use this research to determine the construct validity of this tool.

The identification of practicing EMEs is also open to debate. While KEEN defines the EME model using general qualitative ideas (Figure 1), the person who exemplifies the spirit of an EME is subjective. Further, this study defines an EME based on self-reporting of job title. That is, an EME working for a company is defined as having a leadership role such as manager or director. The non-EME is based on the title of engineer. There may be instances where an engineer does have EME characteristics but is working as an engineer. These anomalies will be considered in the data analysis by comparing variations within and between the groups if there are no significant differences between the groups.

This study will not attempt to evaluate the extent to which self-identified engineering managers are effective leaders. This is not a study on leadership, nor will it define and assess leadership skills. The EME group will be defined as a person having a leadership role; it will not assess whether that person is an effective leader.

Assumptions

For the purposes of this study, the demographic category of engineering manager or leader will define a person who graduated with an engineering degree and is working in a company as a manager, director, or other leadership position. This person is assumed to have entrepreneurially-minded engineer characteristics.

The survey instrument is self-reporting, and it is assumed that respondents are honest with their answers. The results will reflect only the summation of the answers provided. Since the participants are volunteers and results are anonymous, there is a reasonable assumption that the participants will answer honestly in the interests of the research. Each participant also receives a copy of his or her individual report. Therefore, it is in their best interests to answer honestly. This assumption will be challenged by conducting a focus group with volunteers. They will be directly asked their opinion as to the ability of the survey to describe their characteristics. This initial study will provide insight into the question of honesty in the responses.

This research assumes that there is a difference between the engineering leaders and practicing engineers. For example, the self-reporting engineers in this study are practitioners who typically do not seek to attain a management position in their company. These are the engineers who fix equipment, design machines or products, and help companies design and manufacture goods. They are reliable and good problem-solvers. Conversely, the engineering leaders, EMEs, are the engineers who want to be the decision-makers for the company. They understand the overall business operation and lead by setting future direction. This is important because companies need individuals who understand both the strategic direction and the technical challenges. The EME has the combination of technical skills and the ability to lead and communicate direction.

Definitions

Entrepreneurially-Minded Engineer (EME), as defined conceptually by KEEN: An entrepreneurially minded engineer (i.e. an engineer instilled with the entrepreneurial mindset) places product benefits before design features and leverages technology to fill unmet customer needs. The purpose of entrepreneurial engineering is to design value-added products and processes that create demand through innovation, resulting in positive cash flow, revenue, and regenerative profits for the enterprise producing the product (Kriewall & Mekemson, 2010).

Entrepreneurially-Minded Engineer (EME), as operationally defined for this research: Self-identified engineers who work in a leadership role in their company, such as manager or director.

Non-EME, as operationally defined for this research: Self-reported engineers who work as an engineer within their company.

Entrepreneur: An entrepreneur is a person that has the ability to do business, have financial skills and a capacity to identify opportunities. He is capable of turning ideas into business, develop a culture that incentives creativity and innovation (Engler & Ribeiro, 2008).

Intrapreneur: Entrepreneurs innovate for themselves, while intrapreneurs innovate on behalf of an existing organization (Carrier, 1996).

TTI Performance DNA^{TM} Survey: Proprietary survey developed by Target Training International, Ltd. as a way to measure a person's behaviors, values and mastery of professional skills.

KEEN: The Kern Family Foundation's Kern Entrepreneurship Education Network, a collaborative group of over twenty private engineering universities (Kern Family Foundation, 2011).

Chapter 2: Literature Review

This chapter examines the body of knowledge that pertains to entrepreneurially-minded engineers and entrepreneurship. The discussion covers four different aspects: the need for a different type of engineer, their characteristics based on entrepreneurs, how to create them, and, finally, a historical perspective on entrepreneurship.

The Need for a New Breed of Engineer

A culture of innovation is a clear advantage for the American leadership position in the world economy; therefore, it is necessary for a growth economy. As Hart and Acs state, "The capacity to innovate allows the United States to stay one step ahead of rigorous global competition in economic sectors where production processes have been routinized" (2011, p. 117). New ideas help companies provide opportunities for jobs and the creation of new markets. As described by Harkema and Schout (2008), *innovation* refers to the act of materializing that opportunity into a change of sorts and the ability of a company to renew itself. While older technologies and processes are replaced, they can open doors to newer, often better jobs. According to Davis and Rose, "Many business leaders believe that innovation is absolutely critical for our nation to survive economically and militarily" (2007, p. 1). As highlighted by Atkinson and Pelfrey in 2010, there is a clear connection between innovation and economic strength: economists recognize new inventions spur economic growth.

There is also an association between innovation and continued competitiveness. Pisano and Shih believe that "Only by rejuvenating its innovative capabilities can America return to a path of sustainable growth" (2009, p. 13). The generation of ideas assures that as the world changes, the country can change with it and thrive as new markets grow. Innovation can be the result of research, as Dr. Geoffrey Nicholson, Vice President of 3M and the Post-It Notes™

product champion, observed: “Research is the transformation of money into knowledge. Innovation is the transformation of knowledge into money” (Faley & Adriaens, 2008, p. 3). That is, innovation for the sake of something new will not necessarily result in jobs creation, but marketable innovation of a new idea will grow companies and the economy. The combination of research and commercialization of new ideas drives financial growth. In a proposed model of economic development, the success of the United States can be attributed to a well-balanced system of high quality scientific research and a vibrant economic culture (Sanders, 2007).

The ability to innovate and drive the economy will, in large part, come from the science and technology fields. One measure of innovation is patent awards. The majority of patent awards are given to corporations instead of individuals (U.S. Patent and Trademark Office, 2011); therefore, companies need more innovative engineers. Lewin, Massini, & Peeters state, “For science and technology-based companies, in particular, exploiting new market opportunities often requires access to engineers and scientists capable of developing new products and technologies, or of adapting existing ones” (2009, p. 907). In 2008, IBM interviewed more than 1000 CEOs of public sector companies worldwide. The study found that CEOs believe that in order to be successful, companies must promote innovation and transformation. The top three factors that impact their businesses are market factors, people skills, and technological factors (IBM, 2008). These three factors are related to the need for a different type of engineer; engineers are the technology leaders for companies, yet they must understand markets by making economically sound decisions and have the people skills to communicate ideas. This is the type of engineer that the Kern Foundation describes as an entrepreneurially-minded engineer. There is clearly a need for EMEs. The author of an article in *International Review of Entrepreneurship* states, “The challenge within any large corporate is how to release the skills, creativity and expertise of its workforce…There is a clear advantage to be gained by the adoption of processes and techniques, which facilitate innovation by networking and supporting those driving entrepreneurship within an organization" (Reid, 2009, p. 83).

It is true that entrepreneurship is an important means to exploit opportunities and stimulate growth by new firm creation (Mueller, 2007), yet the entrepreneurial spirit and skills are critical for large corporations, not just small start-up ventures. As early as 1969, Westfall studied 35 different firms and their reactions to the new venture concept. He found that corporations were stifled by their own perceptions of new business ventures and described a "circle of non-entrepreneurship" (Westfall, 1969, p. 241). At that time, management failed to recognize the importance of entrepreneurship skills in its work force, yet management consultants and academics realized those skills were critical for companies to thrive. It was a narrow view of entrepreneurship; those characteristics are just as important for employees of all levels of corporations to contribute to the business. As Karanian states, "Although there are many ways that the leader differs from the entrepreneur, research and preliminary data suggests a unique blend of both for the 21st century workplace" (2007, p. 3).

Companies benefit from entrepreneurial thinking, thus the term of "intrapreneur" to describe someone who works within a company and who exhibits the characteristics of an entrepreneur. These are the employees who do things on behalf of the organization, not themselves (Carrier, 1996). According to Pistrui, "Firms that compete on innovation are led by people who have the entrepreneurial mindset" (2007). The term *intrapreneur* began to be referred to in literature and was credited to Gifford Pinchot. In 1982, an article in the Marketing News cited Pinchot's term in the context of a company's ability to innovate will be unsuccessful unless managed properly (Corporate ventures need to be guided by 'Intrapreneurs', 1982). The term then went on to be used in literature to describe the tie between intrapreneurship and corporate creativity and innovation versus individual entrepreneurship. The intrapreneur is the person who is an entrepreneur working in a company that he or she does not own, yet they are performing tasks that benefit that company.

The importance of the intrapreneur became the focus of research as the link to a company's economic successes due to innovation. Menzel, Aaltio, and Ulijn claim, "Entrepreneurship and corporate entrepreneurship [intrapreneurship] are, in many cases, the basis of technological innovations and firm renewal" (2007, p. 740). The company employee who possesses the entrepreneurial skills will often lead the innovation that leads to a company's success. This speaks to the importance of having entrepreneurial characteristics within a large corporation.

Characteristics of an Entrepreneurially-Minded Engineer

Numerous studies describe characteristics of successful entrepreneurs, and many of those are skills that a good EME possesses. A summary of those studies is presented in Table 4 ***Entrepreneurship Characteristics***Based on these studies, the most common characteristics of entrepreneurs are imagination and creativity, the acceptance of risk and failure, aspirations beyond current capability or the ability to think into the future, being team-oriented, proactiveness, and perseverance. The summary also highlights that there is no "one" definition of the entrepreneur or intrapreneur; the common characteristics are determined by which are referenced the most. It is clear that entrepreneurs possess many characteristics. Lazear's seminal research on entrepreneurship deemed this his "jack-of-all-trades" theory (Lazear, 2002). He theorized that entrepreneurs do not excel in one specific skill; they are multifaceted, which supports other research that does not single out one characteristic as being more important than others.

Table 4

Entrepreneurship Characteristics

	Stopford/Baden-Fuller, 1994	Lumpkin/Dess, 1996	Wennekers/Thurik, 1999	Karanian, 2007	Ko/Butler, 2007	Ulijin, 2007*	Okudan/Kisenwether/Rzaza, 2011	Pistrui/Layer/Dietrich, 2012**
Imagination/creativity			x	x	x	x	x	
Acceptance of risk/failure		x	x			x	x	
Aspirations beyond current capability	x						x	x
Team oriented	x						x	
Proactiveness	x	x				x		
Perseverance			x			x	x	
Leadership							x	x
Communication							x	
Capability to resolve dilemma	x						x	x
Autonomy		x				x		
Competitive		x	x					
Connection				x	x			
Character				x		x		
Open-minded toward other cultures			x			x		
Market knowledge/customer oriented						x	x	
Persuasion								x
Learning capability	x							
Innovation		x						
Family/cultural background				x				
Expectation for confrontation				x				
Valuation of wealth			x					
Alertness to opportunity					x			
Prior knowledge and experience					x			
Associative thinking					x			
Internal motivation						x		
Business skills							x	
Engineering skills							x	
Flexibility								x
Goal Orientation								x
Employee Development/Coaching								x
*Intrapreneur ** EME								

The definitions of these types of individuals are primarily qualitative; the research is summarized based on observation. For example, the EME is an engineer who has mastery of the following skills: Technological Fundamentals, Customer Awareness, Business Acumen, and Societal Values (Pistrui & Fry, 2011); which is commonly used by the Kern Foundation to describe the type of engineer who will be the successful entrepreneur or intrapreneur. This can be illustrated by adapting Jeffry Timmons' definition of a successful entrepreneur (1994, p. 25). Engineers may not be inherently innovative, but those who are may become inventors. Engineers who develop good business acumen may become managers. But those who master both will be the EMEs of the future. Marshall pointed out that there is a need to encourage innovation in creating learning environments, saying, "as human beings, our genius lies not in predicting the future but in imagining and creating it" (2010, p. 48).

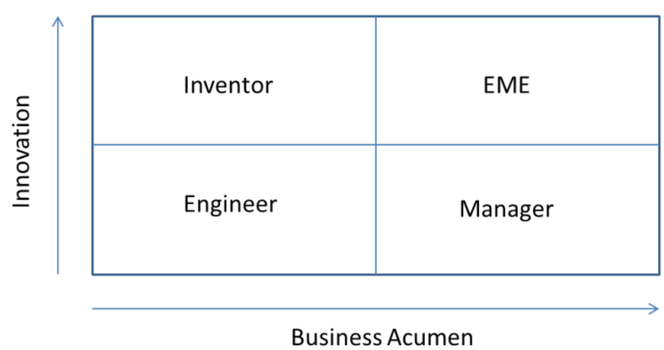


Figure 3. Taxonomy of an EME

Another characteristic of a successful EME is the ability to determine risk and become successful in light of that risk. Often entrepreneurs are catagorized as "risk takers," which is misleading; successful entrepreneurs will assess risk and move forward, understanding the threats as best as possible. Reimer & Pierce state, "Great leaders are often innovators willing to break ground and take the calculated chance to create or move forward in a new direction" (2010). Another way to describe this is to be comfortable and accept an environment of change.

Mathews and Zander view a characteristic of entrepreneurship as the ability to embrace genuine uncertainty (2007). This was also specifically highlighted in a 2007 perspective of entrepreneurship: "Scholars need to develop an integrated perspective of entrepreneurial opportunities that emphasize the creation of uncertanty as a strategy" (Companys & McMullen, 2007, p. 318). Richardson and Hynes (2008) included both risk taking and managing change when describing management skills necessary for economic development.

Creating an Entrepreneurially-Minded Engineer

Engineering education has evolved over time as various technologies and new discoveries impact and challenge the status quo. Grayson (1977) summarizes the major time periods of engineering education as

- The Beginning, 1862 and before
- The Period of Growth, 1862 – 1893
- The Period of Development, 1893 – 1914
- The Period of Evaluation, 1914 – 1940
- The Scientific Period, 1940 – 1968
- Present State: The Period of Social Involvement.

The early period of American engineering education involved the needs of the growing nation for infrastructure, such as roads and later railroads. It was also highly influenced by the military needs of early America from the Revolutionary War to the Civil War. West Point educated engineers on the order of President George Washington (Grayson, 1977). The continued growth of the nation brought a need for more trained engineers. In the early twentieth century, significant inventions like Henry Ford's assembly line and the Wright Brothers' flying machine created new interest in the technical fields. In the mid-century, the space race captured the imagination of many future engineers.

The rise of the middle class in America influenced more people to look to a college education as a source of both knowledge and authority. Professionals in engineering, medicine, and law believed scientific knowledge was essential in the improvement of America (Seely, 2005). Engineering educators were influenced in the 1950s by the increase of federal funding toward scientific research, during which time more science was added to the fundamental base of engineering curricula (Seely, 2005). The increased emphasis on the sciences began to departmentalize the various disciplines in engineering such as physics, chemistry, and mechanics. Forrester noted in 1967 that the rigor of these subjects had led to the inability of the student to see the relationships between them. Engineers needed to innovate, which would require the ability to see synergies between the sciences and how they interacted with one another to change existing technologies into new (Bordogna, Fromm, & Ernst, 1993).

Engineering education followed and changed from both technological and social influences. Grayson's assessment in 1977 indicated that engineering took on more social responsibility than in the past, and engineers were challenged to assess how their inventions or improvements would affect society or the end-user. One could argue that is still true today. Warner (2009) submits that technology education is still trying to incorporate the social sciences into the curricula. He acknowledges that standards in technology education drove some changes in early 2000, and many of those changes recognized the importance of the human side of engineering. This integration is viewed as critical in creating a better engineer. In a 2005 National Academies of Science report, they highlight the critical blend of engineering and social responsibility, saying "Engineers need to understand how to work in teams to be effective, consideration of social issues is important to engineering" (National Academy of Science, 2005, p. 8).

Engineering educators understand that industry wants "engineers who can not only function effectively in a culture of continuous improvement, but who can help form and lead such a culture…" (Prados, 1998, p. 7). Therefore, there is a need for change in engineering education. The technology teachers have recognized this need and "in fact, technology education teachers and engineers are now joining forces and promoting the integrative, multi-disciplinary style of thinking…" (Roman, 2004). The American Society of Engineering Education has launched a multi-year study to study and improve engineering education, stating, "We also should not be complacent and assume that what has worked in the past will continue to work in the future" (American Society for Engineering Education, 2012, p. 9). Many examples can be found in journals and conference proceedings for new engineering design courses. One such example from Clemson University integrates whole-systems thinking in a first-year engineering design program with a focus on sustainability (Blizzard, Klotz, Pradhan, & Dukes, 2012). The program also partners with industrial companies to provide real-world problems for students to work on.

Educated individuals create a work force that companies need to establish an innovative culture and benefit the economy. "The presence of an educated work force is the decisive factor that explains the inventive output of cities," claim Carlino, Hunt, Duranton, and Weinburg (2009, p. 66). Therefore, to create the employees that companies need, engineering education is recognizing the demand and beginning to adjust their programs to include more skills that go beyond basic engineering principles and design. The accreditation board for engineering programs, Accreditation Board for Engineering and Technology (ABET), has recognized this need and integrated some entrepreneurial characteristics into their student outcomes (ABET a-k), such as the ability to work on multi-disciplinary teams, communication skills, and lifelong learning (ABET, 2011). This need to integrate more broad-based engineering curricula began by listening to industry and what companies wanted in their engineers. A 2001 study from Penn State's Center for the Study of Higher Education found that employers were looking for engineers with a broader educational background, not just technical engineering skills (Bjorklund & Colbeck, 2001). A further commentary on the ABET skills believes that "the mastery of these professional skills combined with the ability to innovate will add sufficient value to U.S. engineering graduates" (Shuman, Besterfield-Sacre, & McGourty, 2005, p. 43). The accreditation board for engineering institutions recognizes this need to change and create better engineers who do have a combination of technical knowledge and more business-oriented professional skills.

Engineering educators took note of the needs of industry and started to examine their programs in light of the call for engineers with entrepreneurial skills and the ability to innovate. The 1990s are recognized as a time of major change in engineering education (Eifert, 1998). Programs and curricula started to change by integrating project-based learning and entrepreneurship programs in the early 2000s. A study of MIT alumni who started their own businesses found that research universities could encourage students to be more entrepreneurial by facilitating their social processes, helping them to enhance their reputation, and training to solve problems (Hsu, Roberts, & Eesley, 2007). The combination of engineering expertise and entrepreneurial skills will improve the graduating engineers. According to Kelly, "In addition to developing an understanding of fundamentals, engineering colleges today are more so than ever interested in finding ways to develop the entrepreneurial spirit within their graduates" (2008, p.

2). A 2011 study by Michigan State University surveyed more than 8,000 students, faculty, alumni, and employers and found that the two most important skills for new employees are communication and decision-making or problem-solving (Crawford, Lang, Fink, Dalton, & Fielitz, 2011). While this study did not focus specifically on engineering graduates, it highlights the need for graduates in any field the fact that communication skills are a key to success as an employee.

"Engineering entrepreneurship" began to appear in literature around the 1990s as there were many small technical company start-ups, which laid the foundation for the marriage between technical skills and business acumen. The research started in management journals and then moved to business and education journals in the 2000s. Engineering educators began to integrate entrepreneurship activities into their teaching methods. "There may also be an important role for developments in education for scientists and engineers to include exposure to issues relating to entrepreneurial activities," state Colombo, Mustar, and Wright (2010, p. 9). Programs for engineering disciplines started to include methods to teach skills beyond the technical engineering proficiencies. Condoor and McQuilling state that "Students with exposure to engineering entrepreneurship will understand vital business aspects including marketing and economics, and key engineering facets such as innovation and performance" (2009, p. 1). This combination is critical in creating engineers who will take the lead in technical innovation for future growth.

According to Clouse and Aniello, "The world is unstable and uncertain, but yet most of our formal education systems teach students how to work and live in a stable and structured, organized world" (2007, p. 2). The focus of engineering education to solve specific, staged problems is no longer adequate training for the employees who will innovate and lead their companies into the future. Fry and Pistrui concur, saying, “It is no longer sufficient to adequately train engineers with excellent left-brained skills – analysis, logical thinking and quantitative thought” (2011). These engineering paradigms are changing in recognition of the fact that it is a combination of skills – not just basic engineering “book knowledge”—that is necessary to encourage innovation. “No one can forecast the topics that engineers will be expected to learn ten years from now,” Tribus adds (2005, p. 1). The fundamental principle of innovation is change; therefore, engineers will need to solve problems that have not even been invented yet. The idea of continuous learning and the process of learning will be a necessity for engineering education curriculums. These are the skills that industry will need for the future, that need to be integrated into the curriculum to build a successful pool of innovation talent (Blessing, Mekemson, & Pistrui, 2008).

Entrepreneurship Research

Entrepreneurship research has typically been studied in terms of its impact on the economy. Academic articles associated with entrepreneurship are found in economic and business journals. Scholars review past literature and provide a summation of the body of knowledge and suggest how research should continue. Low and MacMillan view entrepreneurship research in six dimensions: purpose, theoretical perspective, focus, level of analysis, time frame, and methodology (Low & MacMillan, 1988). Bull and Willard (1993) suggest the research may be stratified into five broad categories: definition, traits, success strategies, formation of new ventures, and environmental factors. This research focuses on the traits in the context of which entrepreneurial traits will be possessed by engineers who go on to attain leadership roles in their companies or in starting their own businesses, or which traits will define an entrepreneurially-minded engineer.

Much of the research on entrepreneurs examines what makes a successful entrepreneurial business and a compelling relationship to innovation. “Successful technologies generally do more than just fulfilling people’s existing demands; they challenge people and show them new possibilities that they did not even think of before” (Mulder, 2006, p. 135). The entrepreneurs are the creators of inventive solutions to problems or identifying new opportunities (Reimer, Ali, & Abro, 2011). Albert Einstein is credited with saying, “Imagination is more important than knowledge” (Harris, 1995). The entrepreneurs are typically associated with new ideas and innovative technologies. “Entrepreneurship thrives on technological advances, organizational change and revolution,” states Pistrui (2003).

There is also evidence of a link between entrepreneurs, innovation, and technology. A 2009 study looked at the relationship between education and innovation using the biographical data from more than 500 individuals identified as inventors or entrepreneurs. Baumol, Schilling, & Wolff (2009) found that inventors are likely to come from engineering, physics, and chemistry/medical backgrounds. While technology is a leading field for entrepreneurship and innovation, there are multiple factors that will influence a successful innovation commercialization (Shane, 2001). As other research confirms, there is not just one characteristic necessary for entrepreneurial success; it is a combination of many. A new technology may not be marketable or present a good business case. The entrepreneur can assess the real commercial need for a new idea and be able to make money providing the service or making the product. He or she understands the value proposition to the customer of a new idea beyond the novelty of the idea alone.

Case studies have also found entrepreneurial success is due to the ability to deal with uncertainty. This confirms the importance of an entrepreneur’s ability to manage risk.

“Successful technology entrepreneurs need to tolerate uncertainty or ambiguity because newness assures a lack of data to eliminate risk,” claims Mason (2008, p. 5). A 2011 case study found that successful entrepreneurs need to deal with ambiguity by successful continuous learning (Burns, Acar, & Datta, 2011). This idea of continuous learning was also cited in a study comparing various organizations and lessons learned in creating entrepreneurship programs. “One of the most important lessons learned was the power of organizational learning when it can be fostered in a synergistic manner” (Eseounu, Wyrick, & Vaccari, 2010, p. 4).

A 2010 case study examined how ability affects incomes for entrepreneurs and employees; comparing cognitive and non-cognitive abilities. Hartog, vanPraag, and van der Sluis concluded that “labor market participants benefit more from their general ability as entrepreneurs than employees. Regarding specific abilities, entrepreneurship is associated with higher returns to technical, social and mathematical ability” (2010, p. 981). The entrepreneurial attributes of those who are looking for a job make those persons more desirable in the labor market. Again, this supports Lazear’s jack-of-all-trades theory. It is the multi-dimensional technical individual who will have better success in the job market. A 2007 study found that a key link to entrepreneurial behavior was not creativity alone; it was the combination of creativity with knowledge, a strong network, and the ability to be alert to new opportunities (Ko & Butler, 2010).

It is clear that there is a relationship between entrepreneurship, innovation, and technology. Further, research supports the identification of entrepreneurial characteristics and their importance in complementing technical skills. There is a combination of academic journals, government studies and industry publications that all support the need for engineering talent to support America’s economic well-being. The history of engineering education shows that engineers can change as society's change. Engineering educators are taking note of this and developing curricula to create engineers who have more entrepreneurial skills. This is the mission of the Kern Family Foundation: to lead this change. The goal is not to create more entrepreneurs directly, but rather through the engineers who have those skills that will make them more valuable to businesses in leading innovation. These businesses will lead innovations and drive economic strength for America.

Chapter 3: Methodology

This chapter will present the study design, population and sampling, survey instrument, and intended data-gathering process. It will also discuss a preliminary study performed as a focus group. The purpose of this focus group was to determine if the TTI survey accurately reflected a person's behaviors, values, and skills.

Study Design

This proposed study is descriptive in nature; participants provided responses to survey questions and the outcome are measures of three major areas: behaviors, values, and professional skills. The answers to questions are summarized in a proprietary process by TTI International, Ltd. The survey was performed online; respondents were sent an invitation including a link and key-code to access the survey. Upon completion of the survey, participants received their specialized results report sent directly to their email address provided. These results were numeric and recorded in a master database. A supplemental survey developed on SurveyMonkey.com was completed at the end of the questions section in order to collect demographic data.

Study Population and Sampling

The population for this study is American engineering graduates who are currently practicing in the business world. The participants must have been awarded an engineering degree in order to qualify to take the survey. Therefore, the basis of conclusions reached by the research will be applicable to engineering graduates, and demographic data will reveal which specific geographic areas of the United States are represented.

The sampling method used will be a nominated, purposive sampling. According to Teddlie and Yu, purposive sampling has two goals:

1. To find instances that are representative or typical of a particular type of case on a dimension of interest
2. To achieve comparability across different types of cases on a dimension of interest (Teddlie & Yu, 2007, p. 80).

Snowball sampling was used to a lesser extent. The number of respondents from the chain of invitations will depend on the number of invitations sent and the number of participants who chose to complete the survey. Each participant was asked to forward the assessment to a practicing engineer; however, the exact number of those forwarded invitations could not be determined.

The sample of engineering practitioners began with the researcher's network representing over twenty-five years of experience in the automotive industry. However, respondents were not limited to the automotive industry, as some practitioners have moved on to other occupations and industries. The participants were invited to share the survey with others in their network. That is, participants were asked to forward the online link to other engineers they knew or worked with, providing they had an engineering degree. Job title was not a criterion for selection, rather an outcome collected as demographic data that was used to sort the responses for data analysis. Therefore, study participants were invited based on the criterion that they have an engineering degree.

Data-Gathering Procedure

The invitation to complete the survey was sent to more than four hundred professionals who have attained an engineering degree. These prospective participants were invited based on the professional contacts of the researcher's network using LinkedIn, the largest online professional networking site in the world (About Us, LinkedIn, 2011). The participants were also invited to share the link to their engineering colleagues. The participant accessed the survey using a link and key-code that allowed the data to remain separate from any other survey responses. At the end of the TTI survey, a link was provided to a group of demographic questions using the online program Survey Monkey:

- What is your current job title?
- Do you have a graduate degree?
- How many years have you worked in your profession?
- Where do you live/work?

The job title will be used to discriminate the group of engineers from the engineering leaders (EMEs). The other questions will be reviewed to determine if there is a correlation of the data results to the demographic groups. The locational information will determine the extent to which these results can be used to represent the country or primarily one area, such as the Midwest.

Survey Instrument External Validity and Reliability

The TTI Performance DNA™ survey was developed by Targeted Training International, Ltd., and has used third party, independent statisticians to validate their questionnaires. The research was conducted in accordance with specifications published in Standards for Educational and Psychological Testing, American Educational Research Association, American Psychological Association, and the National Council on Measurement in Education (TTI, Ltd., 2011).

The validity of the survey will determine if the survey is measuring what it is intended to measure. The TTI survey has been refined over the years based on factor analysis, which compares and analyzes inter-relationships of data (TTI, Ltd., 2011). Similar surveys are also used to compare outcomes and refine question/answer relationships.

This type of instrument is a self-reporting method, which will report accurately only to the degree that the respondent is honest with answers. Therefore, participants are encouraged to answer honestly to their best ability. The reliability of the test method typically refers to the consistency of the results. Since participants self-report, the reliability of the results (or consistency) would be based on the extent to which a person's characteristics may change over time. This could be affected if a person answers based on situation, such as whether he or she were in a work or home environment. The TTI survey addresses this by discriminating a person's natural versus adapted style in the first section of the survey using the DISC instrument. Respondents may have a natural tendency or like to avoid conflict; however, they achieve a management position at work that requires a more dominant personality, so they adapt more to that style in a work environment. Scale reliabilities were calculated using Cronbach's alpha, which models internal consistency based on the average inter-item correlation and range between 0.826 to .885 (N=16,950; TTI, Ltd., 2011).

Confidentiality and Human Subjects

The Eastern Michigan University Human Subjects Review Committee has reviewed the data-gathering procedure and provided an exempt approval (Appendix A), and the researcher takes responsibility for the protection of the human subjects. The invitation described the condition of anonymity, as no specific names would be used in the research and survey results would be used only in aggregate (Appendix B). The Human Subjects review is intended to protect the participants from any adverse effects of taking the survey and to comply with confidentiality requirements.

Data Analysis

The survey results provide a numeric outcome in each of the three sections. The results for the DISC assessment on behaviors will be a 0-100 output for both the adapted and natural style for the four indicators: Dominance, Influencing, Steadiness, and Compliance. For this research, only the results from the natural behaviors will be used. The values are also a 12-72-point scale for six indicators: Theoretical, Utilitarian, Aesthetic, Social, Individualistic, and Traditional. The numeric output for the 23 professional skills is based on a 0-10 scale, reflecting the extent to which the person has mastered each skill. These data will be analyzed using multivariate calculations to determine if there is a difference in these outputs between the entrepreneurially-minded engineer group and the engineers. If the data sets do not follow a normal distribution, nonparametric methods will be used.

The demographic data will be collected using the following scale:

Table 5

Demographic Data

	1	2	3	4	5
Title	Engineer	Manager/Director Leadership	Entrpreneur	Other	
Grad. Degree	No	MBA	Other Masters	PhD	Professional Certification
Time on Job	1 - 5	6 - 10	11 - 20	21 - 30	30 +
Area	Midwest	South East	South West	North East	North West
Public/Private	Public	Private			

The primary data analysis model will determine whether the two groups can be differentiated using the survey behaviors, values, and professional skills outcomes or the demographic data. The groups will be compared using a statistical test to compare two independent samples for the EME/non-EME groups. This data analysis concept can be illustrated as follows:

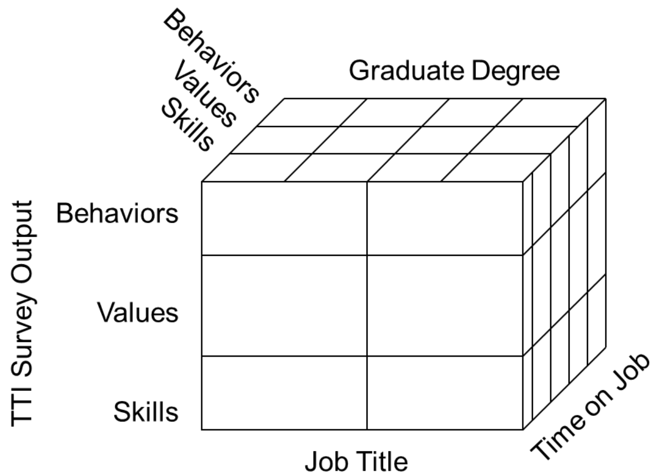


Figure 4. Data Analysis Model

It is expected that there may be overlap of characteristics between EMEs, engineers, and entrepreneurs. If there is a significant difference between the EME and non-EME groups, results of the analysis of the data collected on EMEs and engineers will be used to describe a unique profile for an EME. This profile can be compared to the existing profiles described both in literature and existing data sets from entrepreneurs. IBM's SPSS Version 20 Statistical Software package is used for the data analysis.

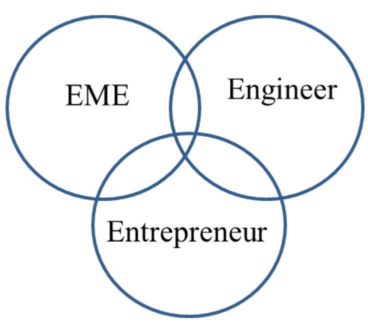


Figure 5. Relationship of Characteristics

Chapter 4: Results

This chapter will present the results of the data analysis. The summary of the numeric outcomes for all behaviors, values, and professional skills will be shown. Next, the demographic data will be analyzed, statistical testing will examine the normality of the data, and then hypothesis testing results will be shown.

Demographic Characteristics of the Sample

The invitation to complete the TTI Performance DNA™ survey was sent to approximately 400 practicing engineers. There were 164 total surveys received. One person answered the survey twice, so the second response was omitted. One person did not complete the demographic questions, so that survey was omitted. A final sample of 162 was collected and appropriate for use. Due to an unknown number of invitations via snowball sampling, the exact return rate cannot be calculated; however, an approximation based on these results is not more than 40%.

Of the 162 responses, 62 self-reported their job title of "engineer." These 62 will define the non-EME group. A total of 77 indicated they had a leadership role by designating a title of manager, director, or other leadership position in their company. These were assumed to be EMEs. Fifteen participants self-reported a title of entrepreneur, which was included in the EME data set. Eight persons reported the category of "other," which included the following written responses:

- President / retired
- Account manager
- Lean Consultant
- Project Manager

- Engineer/Quality manager
- Vice President
- Senior Consultant
- CFO

These eight persons were included in the EME data set due to their current job title indicating a leadership role. The total sample for the EME data set is 100, and the total result is illustrated below.

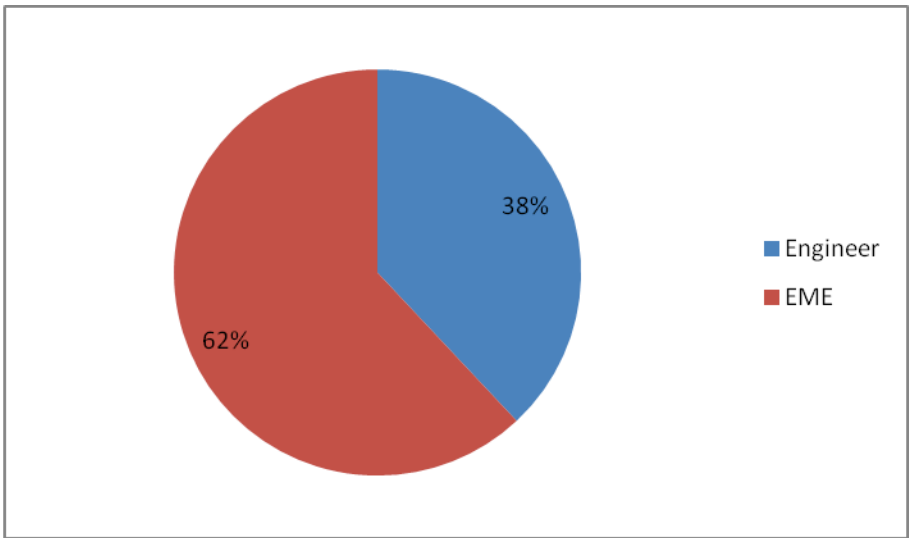


Figure 6. Survey Responses by Job Title

Below are the responses for the graduate degree designation. For those who reported multiple responses, the first response was used. For example, if a respondent indicated he had an MBA degree and professional certification, only the MBA designation was used.

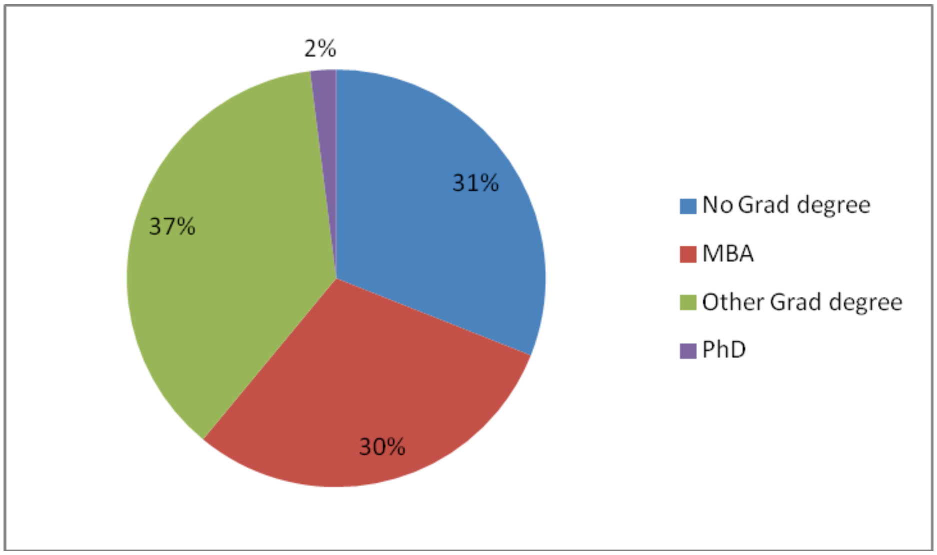


Figure 7. Survey Responses by Graduate Degree

The respondents also indicated the areas of the country where they lived and worked. All respondents were from the United States. More than half of the respondents were from the Midwest. The responses are illustrated below.

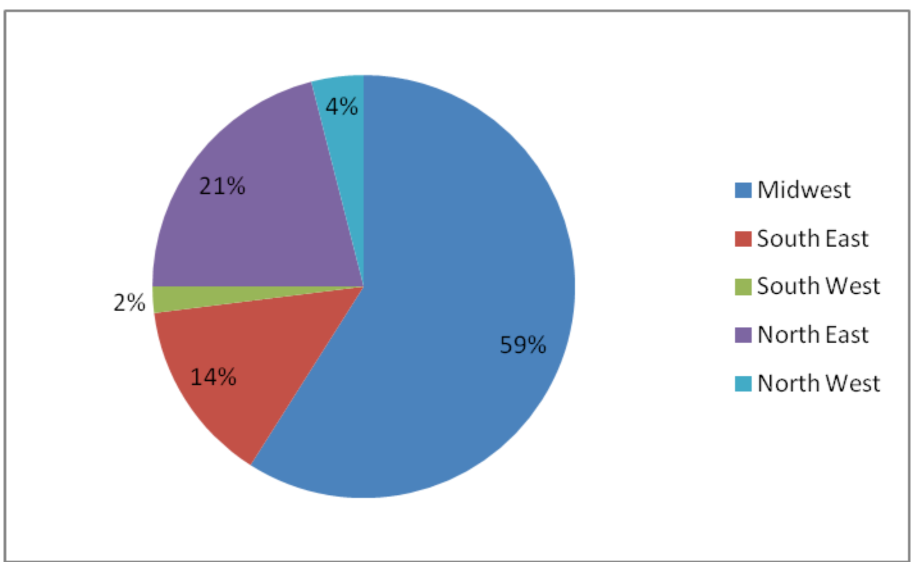


Figure 8. Survey Results by Area

In order to determine if it is reasonable to project the study conclusions to all parts of the United States, the data were compared across these regions. There was no significant difference in the DISC behaviors, no difference in the values, and only two of the 23 professional skills were significantly different: creativity and continuous learning. Therefore, it is reasonable to conclude that the survey results adequately describe engineers throughout the United States since there was no significant difference between the regions. Conclusions can represent a national population.

Respondents were asked to indicate the number of years they had on the job. Half of them had 21 – 30 years on the job, a high seniority and experience level.

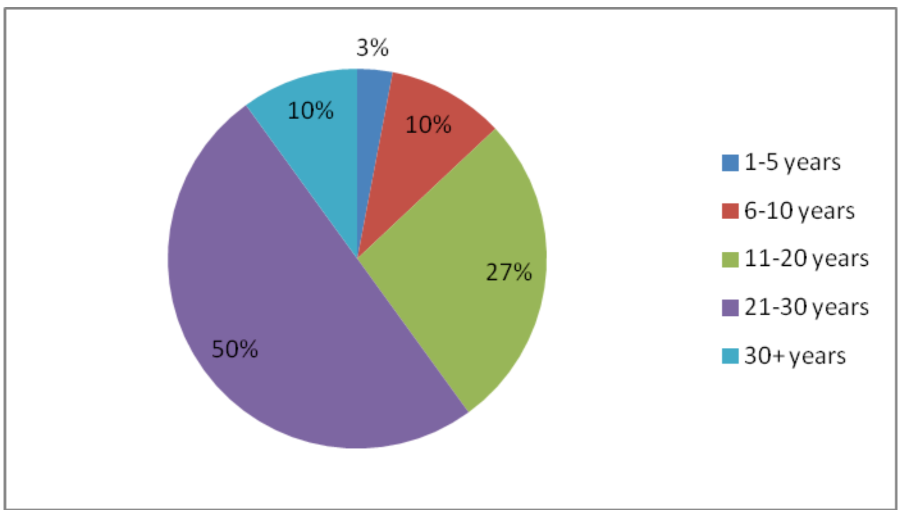


Figure 9. Time on Job

Respondents were also asked if they started their own business. In the EME data set, 56% of respondents reported never starting a business, and 14% reported they had started a business prior to the job they had currently. In the engineer database, 70% of respondents reported they had never started a business, and 14% reported a prior business. This question was treated independently of the question of job title; that is, if a person reported that he was an engineer but started a business, he was still categorized as an engineer. It is assumed in this case that his job as an engineer, not an entrepreneur, is their primary career. The EME database was treated the same; that is, only those respondents who listed their current job title as a business owner or entrepreneur are considered in the EME database.

Data Reliability

The TTI Performance DNA™ Survey results were divided into three separate sections: Behaviors (DISC), Values, and mastery of Professional Skills. Each of these sections was analyzed separately. A measure of internal consistency or reliability was popularized by Cronbach (1951) using a measure developed by Kuder and Richardson's coefficient alpha. This became known as Cronbach's alpha and is used as a reliability indicator. For general research, it is accepted to use data that result in a Cronbach's alpha of greater than 0.7 (Nunnally, 1978, p. 245).

The four DISC variables taken together resulted in a negative value of Cronbach's alpha. This outcome is similar to other research by Minder, Schneider-Yin, and Minder (2010) and Margari, Matarazzo, Casacchia, Roncone, Diece, Safran, Fiori, and Simoni (2005), which was found due to the DISC variables representing multiple causes rather than multiple effects. These two studies showed a negative Cronbach's alpha for behaviors defined from a personality survey. That is, the DISC variables represent an individual's behaviors, not a result or outcome. Behaviors are the underlying causes to actions. The previous sources found a negative Cronbach's alpha when looking at various behaviors related to each other. The four behaviors are not expected to be consistent with one another for multiple respondents. This is also true for the six values variables; they are causes for outcomes and not consistent with one another. This was also examined in a 2012 study in which all 33 variables together were found to have a negative Cronbach's alpha (Pistrui, Layer, & Dietrich, 2012). In this case, the data were coded to eliminate the negative covariance, which resulted in a Cronbach's alpha value of 0.718. This coding eliminated the negative relationship of some behaviors and values.

The 23 professional skills are the effects, or outcomes, of both behaviors and values (although not exclusively). The Cronbach's Alpha calculated for these 23 professional skills was 0.80, which exceeds the criterion cited by Nunnally for goodness of use in general research. Therefore, the 23 professional skills are reliable measures to use for this analysis with respect to internal consistency as measured by Cronbach's alpha. Although the behaviors and values do not fit the criteria of internal consistency defined by Cronbach's alpha, they will not be excluded from the assessment in determining the differences between the EME and non-EME groups. It is not expected that grouped behaviors or values would result in a positive internal consistency measure.

Data Analysis

The data were analyzed using IBM's SPSS Version 20 Statistical Analysis software. The data were separated into the two main groups: non-EMEs and EMEs. The resulting averages were calculated as a measure of central tendency, and the measure of variation was calculated as a standard deviation for each group. The resulting data for behaviors are shown below. In these results, the EME group showed higher results for the dominance behavior, and the non-EME group scored higher in the remaining three behaviors. Hypothesis tests are conducted below to determine if these differences are statistically significant.

Table 6

Results for Behaviors

	non-EME		EME	
	n=62		n=100	
	Ave.	St.Dev.	Ave.	St.Dev.
D	41.08	20.81	47.38	18.74
I	51.29	18.94	50.94	20.28
S	63.24	16.21	56.67	18.39
C	53.74	18.21	53.52	19.21

The resulting data for the six values are shown below. The EME group showed higher results in the utilitarian and individualistic values, while the non-EME group was higher in the remaining values. The statistical tests to determine if these differences are significant will follow with the hypothesis tests.

Table 7

Results for Values

	non-EME		EME	
	n=62		n=100	
	Ave.	St.Dev.	Ave.	St.Dev.
Theoretical	49.05	10.18	48.71	9.59
Utilitarian	48.34	9.89	52.33	10.69
Aesthetic	33.27	10.15	32.39	9.42
Social	43.60	10.99	41.10	9.26
Individualistic	38.11	10.14	39.90	8.68
Traditional	39.63	9.67	37.57	9.29

The results for the professional skills are shown below. The EME group showed higher mastery of professional skills in most categories with the exception of interpersonal skills, written communication, customer service, and empathy. The significance testing follows in the hypothesis tests.

Table 8

Results for Skills

	non-EME		EME	
	n=62		n=100	
	Ave.	St.Dev.	Ave.	St.Dev.
Leadership	4.68	2.28	6.31	2.06
Employee Development	6.10	1.96	6.89	1.92
Teamwork	6.83	1.71	7.08	2.03
Conflict Management	4.36	1.91	5.48	2.17
Interpersonal Skills	6.02	2.91	5.96	3.00
Problem Solving	5.21	1.62	5.66	1.96
Creativity/Innovation	4.03	2.45	5.12	2.62
Written Communication	5.50	2.12	5.32	2.21
Customer Service	6.88	1.51	6.23	1.85
Flexibility	3.67	2.29	4.32	2.37
Goal Orientation	6.13	1.63	7.10	1.74
Planning/Organizing	5.16	2.09	5.44	2.20
Diplomacy	5.80	1.85	6.16	1.92
Personal Effectiveness	4.78	1.85	5.46	2.04
Presenting	4.31	2.63	5.96	2.72
Management	4.92	1.62	5.59	1.70
Negotiation	2.84	2.60	3.51	2.47
Persuasion	3.85	2.47	5.26	2.30
Empathy	3.32	1.95	3.19	2.19
Continuous Learning	6.05	1.97	6.27	1.98
Futuristic Thinking	2.36	2.02	3.07	2.38
Decision Making	3.14	2.27	4.05	2.28
Self-Management	4.08	2.46	4.94	2.50

Each of these data groups was analyzed for normality. Normality is an assumption for parametric statistical testing; therefore, this assumption must be assessed in order to determine if the parametric test is valid to use. The Kolmogorov-Smirnov test for normality was used based on the following hypothesis statement:

H_0: The distribution follows a normal distribution

H_1: The distribution does not follow a normal distribution

The normality of the distribution will determine what statistical methods to use for comparison. Below are the alpha value results for the behaviors, values, and professional skills, segregated by EME and non-EMEs. The highlighted p-values in the chart below show which distributions are rejected for normality at a 95% confidence, or alpha value 0.05 or below, which indicates that the distribution is not normal. Therefore, the null hypothesis is rejected for Dominance in the non-EME group and Influence for the EME group. For the behaviors, there are only two non-normal distributions. Since the non-EME and EME groups are being compared to each other, an assumption of normality cannot be met comparing the Dominance and Influence behaviors.

Table 9

Behaviors Test for Normality p-values

	non-EME	EME
D	0.007	0.137
I	> 0.20	0.04
S	> 0.20	0.131
C	0.166	0.098

For the six values, the null hypothesis is rejected for Utilitarian and Aesthetic for the EME group and the Traditional for the non-EME group. Therefore, the assumption of normality is not met when comparing the Utilitarian, Aesthetic, and Traditional values.

Table 10

Values Test for Normality p-values

	non-EME	EME
Theoretical	> 0.20	> 0.20
Utilitarian	> 0.20	0.003
Aesthetic	> 0.20	0.014
Social	> 0.20	> 0.20
Individualistic	> 0.20	> 0.20
Traditional	0.011	0.122

The 23 professional skills p-values for the test of normality are listed in Table 11. The highlighted values are the instances where the null hypothesis is rejected, resulting in a non-normal data set. In these cases, the assumption of normality cannot be met. Based on these results, the only skills that have both non-EME and EME groups normally distributed are flexibility, planning/organizing, diplomacy, negotiation, persuasion, continuous learning, and decision-making. Therefore, most of the skills cannot be compared using a test that assumes normality.

Table 11

Skills Tests of Normality p-values

	non-EME	EME
Leadership	> 0.20	0.049
Employee Development	> 0.20	0.005
Teamwork	0.001	0.008
Conflict Management	> 0.20	0.086
Interpersonal Skills	0.083	0
Problem Solving	> 0.20	0.04
Creativity/Innovation	> 0.20	0.043
Written Communication	0.021	0.068
Customer Service	> 0.20	0.005
Flexibility	> 0.20	> 0.20
Goal Orientation	0.005	0.1
Planning/Organizing	> 0.20	0.103
Diplomacy	> 0.20	0.051
Personal Effectiveness	0.077	0.038
Presenting	0.083	0.003
Management	0.008	0.003
Negotiation	0.144	0.058
Persuasion	0.058	0.127
Empathy	0.034	0.067
Continuous Learning	> 0.20	> 0.20
Futuristic Thinking	0.023	0.004
Decision Making	0.185	0.147
Self-Management	> 0.20	0.071

Due to the low number of distributions that follow a normal distribution (less than half, 12/33 comparisons), a nonparametric analysis is used for all data sets for consistency and comparison. A nonparametric analysis does not use the normality assumption; therefore, results will not be compromised because the normality assumption cannot be met for most of the data sets. The distributions of the data sets are found in Appendix C.

Hypothesis Testing

Each of the three hypothesis statements will be assessed in this section. The hypothesis test will be presented for each of the behaviors, values, and professional skills. The Mann-

Whitney U nonparametric testing for two independent samples is used; this does not assume normality of the groups. The numeric outcome of each of the four behaviors, six values, and 23 professional skills were assessed to determine if there is a difference between the engineer and entrepreneurially-minded engineer groups based on their self-reported answers to the survey questions.

Hypothesis One.

$H_{0:}$ There no difference between the EME and non-EME groups in terms of behaviors, values, and skills.

H_1: There is a difference between the EME and non-EME groups in terms of behaviors, values, and skills.

Table 12

P-values for Behaviors non-EME v. EME

	p-value	Conclusion
D	0.026	Reject
I	0.929	Do not reject
S	0.031	Reject
C	0.460	Do not reject

Using the nonparametric Mann-Whitney U test and 95% confidence, the Dominance and Steadiness factors are significantly different between non-EMEs and EMEs. There is no significant difference between the Influence and Compliance behaviors. Two of the four, or half, of the behaviors show a difference between the non-EME and EME groups.

Table 13

P-values for Values non-EME v. EME

	p-value	Conclusion
Theoretical	0.889	Do not reject
Utilitarian	0.011	Reject
Aesthetic	0.605	Do not reject
Social	0.147	Do not reject
Individualistic	0.294	Do not reject
Traditional	0.387	Do not reject

For the six values, there are no significant differences between the non-EME and EME groups, with the exception of the Utilitarian category. With 95% confidence, there is only one significantly different value when comparing non-EMEs and EMEs.

Table 14

P-values for Skills non-EME v. EME

	p-value	Conclusion
Leadership	0.000	Reject
Employee Development	0.015	Reject
Teamwork	0.185	Do not reject
Conflict Management	0.003	Reject
Interpersonal Skills	0.966	Do not reject
Problem Solving	0.066	Do not reject
Creativity/Innovation	0.014	Reject
Written Communication	0.490	Do not reject
Customer Service	0.027	Reject
Flexibility	0.053	Do not reject
Goal Orientation	0.001	Reject
Planning/Organizing	0.387	Do not reject
Diplomacy	0.213	Do not reject
Personal Effectiveness	0.021	Reject
Presenting	0.000	Reject
Management	0.012	Reject
Negotiation	0.077	Do not reject
Persuasion	0.000	Reject
Empathy	0.639	Do not reject
Continuous Learning	0.573	Do not reject
Futuristic Thinking	0.059	Do not reject
Decision Making	0.020	Reject
Self-Management	0.039	Reject

For the 23 professional skills, there are 12 categories that are significantly different between the non-EME and EME groups in which the null hypothesis was rejected. These are all significantly different at a 0.05 alpha level, 95% confidence. For a further level of discrimination, using a 99% confidence level or 0.01 alpha, there are five significantly different categories: leadership, conflict management, goal orientation, presenting, and persuasion. Using a 99% confidence level, it shows that there is a stronger difference or more statistically different. Therefore, these five categories show more of a difference than those at a 95% confidence level.

From these analyses, it is clear there is a difference between the non-EME group and the EME group based on their professional skills since over half of the skills are different between the two groups.

Hypothesis Two.

H_0: There is no difference between the EME and non-EME groups in terms of time on the job or graduate degree attainment.

H_1: There is a difference between the EME and non-EME groups in terms of time on the job or graduate degree attainment.

The second hypothesis is to determine if there is a difference between the responses when evaluated based on the length of service the person had on the job. That is, do these indicators change over time with experience? Further, is there a difference in the behaviors, values, and skills if the respondent has attained a graduate degree? The nonparametric test for multiple responses of the Kruskal-Wallis test was used based on the multiple responses for each question of time on the job and graduate degree attainment.

Table 15

P-values for Behaviors time on job and graduate degree attainment

	Time on Job			Graduate Degree Attainment	
	p-value	Conclusion		p-value	Conclusion
D	0.998	Do not reject		0.279	Do not reject
I	0.818	Do not reject		0.652	Do not reject
S	0.971	Do not reject		0.379	Do not reject
C	0.544	Do not reject		0.545	Do not reject

The assessment of the behaviors shows that the null hypothesis is not rejected in all comparisons. Therefore, with 95% confidence, there is no significant difference in behaviors when comparing time on the job and graduate degree attainment.

Table 16

P-values for Values time on job and graduate degree attainment

	Time on Job			Graduate Degree Attainment	
	p-value	Conclusion		p-value	Conclusion
Theoretical	0.473	Do not reject		0.118	Do not reject
Utilitarian	0.904	Do not reject		0.319	Do not reject
Aesthetic	0.286	Do not reject		0.519	Do not reject
Social	0.760	Do not reject		0.897	Do not reject
Individualistic	0.371	Do not reject		0.916	Do not reject
Traditional	0.936	Do not reject		0.259	Do not reject

The assessment of values shows that the null hypothesis is not rejected in all comparisons. Therefore, with 95% confidence, there is no significant difference in all six values when comparing time on the job and graduate degree attainment. The values do not change when considering time on the job or whether the individual had a graduate degree.

Table 17

P-values for Skills time on job and graduate degree attainment

	Time on Job			Graduate Degree Attainment	
	p-value	Conclusion		p-value	Conclusion
Leadership	0.627	Do not reject		0.056	Do not reject
Employee Development	0.536	Do not reject		0.323	Do not reject
Teamwork	0.471	Do not reject		0.937	Do not reject
Conflict Management	0.924	Do not reject		0.745	Do not reject
Interpersonal Skills	0.319	Do not reject		0.761	Do not reject
Problem Solving	0.182	Do not reject		0.270	Do not reject
Creativity/Innovation	0.547	Do not reject		0.054	Do not reject
Written Communication	0.297	Do not reject		0.494	Do not reject
Customer Service	0.948	Do not reject		0.471	Do not reject
Flexibility	0.743	Do not reject		0.182	Do not reject
Goal Orientation	0.849	Do not reject		0.232	Do not reject
Planning/Organizing	0.016	Reject		0.095	Do not reject
Diplomacy	0.853	Do not reject		0.178	Do not reject
Personal Effectiveness	0.072	Do not reject		0.801	Do not reject
Presenting	0.256	Do not reject		0.000	Reject
Management	0.602	Do not reject		0.248	Do not reject
Negotiation	0.327	Do not reject		0.570	Do not reject
Persuasion	0.544	Do not reject		0.052	Do not reject
Empathy	0.538	Do not reject		0.263	Do not reject
Continuous Learning	0.022	Reject		0.359	Do not reject
Futuristic Thinking	0.399	Do not reject		0.058	Do not reject
Decision Making	0.919	Do not reject		0.856	Do not reject
Self-Management	0.428	Do not reject		0.411	Do not reject

The null hypothesis is not rejected in all cases of professional skills when comparing time on the job and graduate degree attainment, with the exceptions of planning/organizing and continuous learning for time on the job and presenting for graduate degree attainment. When evaluated based on time on the job, the results indicated no significant difference in the DISC results, no significant difference in the values, and only two significant differences in professional skills: planning/organizing and continuous learning. These two skills were significantly different at a 95% confidence, not 99% confidence. Therefore, it is reasonable to conclude that time on the job does not affect behaviors, values, and professional skills of engineers. Further, considering graduate degree attainment, only one professional skill is found to be significantly different: presenting. Therefore, graduate degree attainment does not affect behaviors, values, and professional skills of engineers.

These analyses strengthen the conclusion that the behaviors, values, and professional skills of non-EMEs can be distinguished when compared to entrepreneurially-minded engineers. These differences cannot be attributed to the time on the job, or whether the engineer attained a graduate degree. Using specifically the behaviors and skills, the two groups of EMEs and non-EMEs are different. That difference is not seen when grouping by graduate degree attainment or time on the job, which suggests that it is not a random occurrence that differences are significant based on various groupings. It is only the grouping of EME and non-EME that result in a significant difference. This suggests that the behaviors and professional skills of engineers are different than engineers in a leadership position. This difference cannot be explained using other indicators, only the differentiation in job position.

Hypothesis Three.

> If there is a difference found between the EME and non-EME groups, define the specific behaviors, values, or skills that differentiate the EME and non-EME groups in terms of which groups are statistically significantly different.

The testing from hypotheses one and two clearly shows there is a significant difference between the non-EME and EME groups that cannot be explained by time on the job or graduate degree attainment. Based on a 95% confidence, there are two behaviors and 12 professional skills that are significantly different. The averages of these categories are shown below. The higher average is highlighted.

Table 18

Averages for non-EME and EME groups

	Average	
	Non EME	EME
Dominance	41.08	47.38
Steadiness	63.24	56.67
Leadership	4.68	6.31
Conflict Management	4.36	5.48
Goal Orientation	6.13	7.10
Presenting	4.31	5.96
Persuasion	3.85	5.26
Employee Development/Coaching	6.10	6.89
Creativity/Innovation	4.03	5.12
Customer Service	6.88	6.23
Personal Effectiveness	4.78	5.46
Management	4.92	5.59
Decision Making	3.14	4.05
Self-Management (time and priorities)	4.08	4.94

The professional skills as shown in bold are those skills that are significant at a 99% confidence level. Therefore, a profile of an EME can be defined as having a high dominance and low steadiness behavior, lower mastery of customer service skills, and higher mastery of

- Leadership
- Conflict Management
- Goal orientation
- Presenting
- Persuasion
- Employee development
- Creativity/innovation
- Personal Effectiveness
- Management

- Decision Making
- Self-management.

In addition to the statistically significant differences using 95% confidence, it is worth discussing the skills that are very close to the 95% confidence level. These are the following along with their p-values:

- Flexibility (0.053)
- Futuristic Thinking (0.059)
- Problem Solving (0.066)
- Negotiation (0.077)

These characteristics are worth consideration due to their proximity of our acceptance criteria. For example, flexibility is significant at a 94.7% confidence level. That is, we are 94.7% confident that there is a significant difference between the engineer and EME groups. As more data are collected, it is reasonable to consider that flexibility may become a significant factor. Therefore, when reviewing the differences between engineers and EMEs in the professional skills, these four should be considered and may become significant when more data are added to the sample.

These results show a distinct difference in the two of the four behaviors and 12 of the 23 professional skills of engineers and entrepreneurially-minded engineers. Both groups have attained an engineering degree, yet they are differentiated by those engineers that chose a leadership path in their profession. The EMEs are distinguishable by showing a high dominance behavior. These individuals will stand out and take charge in a situation. This supports their drive to be in a leadership position. The different professional skills also support leadership characteristics including persuasion, innovation, management and decision making. These data, which result from the TTI Performance DNA™ survey, show that it is possible to distinguish between these two groups of professionals using behaviors and professional skills. This statistical analysis shows the ability to not only differentiate non-EMEs and EMEs, but specifically describe the EMEs' strengths in terms of professional skills.

Chapter 5: Conclusions and Recommendations

This chapter will discuss the conclusions reached from the previous statistical hypothesis testing results. The discussion will present implications of the research, and recommendations will be presented in the interest of further research.

Conclusions/Discussion

The statistical testing showed that there were distinct differences in the engineer or non-EME and entrepreneurially-minded engineer groups in terms of two of the four behaviors and 12 of 23 professional skills. These differences were not present when the groups were separated based on time on the job and whether the respondents had a graduate degree, indicating that the differences could not be explained by whether the person had attained a graduate degree or how much time he or she had on the job. It is reasonable to conclude that the behaviors and professional skills measured in the TTI Performance DNA™ survey are sufficient to distinguish between non-EMEs and EMEs. The statistical hypothesis test results support affirmative answers to the original research questions:

1. Is there a difference between the behaviors, values, and professional skills of entrepreneurially-minded engineers (EME) and engineers (non-EME), or are these groups different due to other factors such as time on the job?
2. Is the TTI Performance DNA™ assessment survey a valid tool to determine these differences?

These results can be illustrated using the original model.

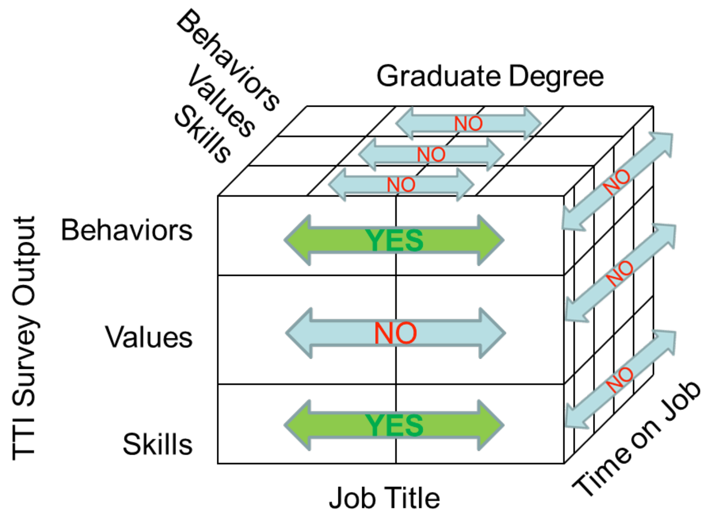


Figure 10. Data Analysis Model Results

Since the tests showed that there is a significant difference between the non-EME and EME groups, the EMEs can be described as possessing a unique set of characteristics. Beginning with behaviors, an analysis of the data revealed that EMEs had a higher dominance (D) score than engineers. The “High D” person is a person who “needs to direct, likes a challenge, has a desire to win, is direct with communication, high risk taker and extroverted” (Bonnstetter & Suiter, 2011, pp. 60-61). These respondents to the survey indicated they held a leadership position with their employer or owned their own business, which is in agreement with the types of characteristics typically associated with the higher dominance behaviors.

The next significant difference for behaviors was the steadiness attribute. In this case, non-EMEs scored higher than EMEs. The “High S” is a person who “needs to serve, is loyal, is patient, relaxed, values long term relationships, needs closure and is introverted” (Bonnstetter & Suiter 2011, pp. 94-95). When compared to the dominance behavior, these results describe two distinct groups, which support the theory that there is a difference between the non-EMEs and EMEs. For example, in terms of behavior style, the EMEs tend to be extroverted (high D), while the non-EMEs tend to be introverted (high S). These differences were not apparent when the responses were grouped based on time on the job or whether the respondents had an engineering degree. They were significant only when the non-EME and EME groups were compared. The attributes of a high D are different than those of a high S, and these results are consistent with the ability to distinguish between non-EMEs and EMEs. The two groups are distinguishable by their behaviors.

There was no real difference regarding the values between the engineers and EMEs except for one significant difference: the value of utilitarian. This shows that EMEs tend to be more utilitarian than engineers, which agrees with the finding of the behavior profile of the high D. There were no other significant differences between the seniority and graduate degree groups for the values. When comparing values, there were not enough significant differences to indicate that non-EME and EME groups can be differentiated in terms of values. This result suggests that engineers do not have different values and that groups of engineers cannot be distinguished from the engineering leaders based on values.

The most significant difference between the non-EME and EME groups was found in the professional skills area. Twelve of the 23 professional skills were significantly different between the two groups. Only two of those were significant based on seniority and one difference between the graduate degree groups. Clearly, the non-EME and EME groups are different and distinguishable in their mastery of professional skills as measured by the TTI Performance DNA™ survey. Just over half of the skills showed a significant difference when compared between the self-reported engineers, categorized as non-EMEs, and those who reported they have a leadership role in their current position, the EMEs.

Of the twelve professional skills that were significantly different, one of them was higher in the non-EME group. The other eleven were higher for EMEs. The one professional skill area in which non-EMEs excelled over EMEs was customer service. This high result for customer service is in agreement with the high S characteristic of non-EMEs. Characteristics of the high S include loyalty and need to serve, which fit with a high skill in the customer service area. The high score of engineers for customer service is in alignment with the high steadiness behavior. These findings support one another because of the commonality in the characteristics of the behavior and the professional skill of customer service.

The remaining eleven professional skills were higher for the EMEs. The skills where EMEs responded significantly higher than engineers, at a 95% confidence level, are employee development/coaching, creativity/innovation, personal effectiveness, management, decision-making, and self-management (time and priorities). These skills reflect individuals who have management roles; they develop employees and make decisions within their company or their own business. The respondents self-reported their job as a management level employee or business owner; therefore, the survey revealed that management level employees are individuals who show higher mastery of these skills. Further, there are four additional professional skills that were close to the 95% confidence level, or significant at a 90% confidence of flexibility, futuristic thinking, problem solving and negotiation. These four should be considered in the case that the list of professional skills would be segregated into just those that showed a difference. They were very close, therefore should always be included in further analysis in the event the researcher would like to use a truncated list of skills instead of the entire list.

A more convincing significant difference was found using a 99% confidence level for five skills: leadership, conflict management, goal orientation, presenting, and persuasion. These skills align with the description of a high D behavior in dealing with people, comfortable in groups, and goal-oriented, or extroverted. Mastery of these skills reflects leadership qualities; these are the engineers who have attained a leadership role in their careers or started their own company. These professional skills enhance engineers' ability to lead groups, present their ideas, and persuade others to see the value in their ideas.

Based on this study, the profile for an EME is somewhat different from that of an entrepreneur. From the literature review, top entrepreneur characteristics are imagination/creativity, acceptance of risk/failure, aspirations beyond current position, being team-oriented, proactiveness, and perseverance (see Table 4). These contrast the top characteristics of EMEs: leadership, conflict management, goal orientation, presenting, and persuasion. There are also some entrepreneurs in the EME database; however, these entrepreneurs who are engineers have a slightly different profile. There are similarities, but the strongest characteristics differ. The difference in the EMEs and entrepreneurs described here are qualitative, based on a review of the literature; however, the TTI assessment can be used to measure the differences using entrepreneurs as participants and comparing the results to the EME group.

The TTI Performance DNA™ assessment is a useful tool in determining the difference in a non-EME and an EME. Based on this research, the most compelling difference is shown in the professional skills, followed by behaviors. The values did not indicate a significant difference between the two groups. These differences in the professional skills could not be found when assessing a person's time on the job or whether he or she had attained a graduate degree. Therefore, the difference shown in professional skills is due to whether a person is a non-EME or EME. Further, these professional skills define a unique profile for the EME. This measurement tool provides a quantitative assessment that can be defined and compared to other populations. Previous studies and research are primarily qualitative in nature; they do not provide specific data for precise measurement. This assessment provides a data-centered instrument that can be used to show an educational program's progress toward creating a more entrepreneurially-minded engineer.

The unique profile of the EME is useful for engineering education. The accreditation board for engineering programs, ABET, has modified their student outcomes to include other non-technical skills, such as communication. However, institutions are not given a means to measure these outcomes directly. Eifert (1998) points out that the ABET requirements will necessitate that institutions measure learning outcomes, not curriculum subject exposure. The TTI survey provides a way to measure student performance in terms of professional skills. This is beneficial because institutions can provide clear, measurable results instead of anecdotal evidence of their program's effectiveness. Further, these student profiles can be compared to the EME profiles described in this research as a way to show a preferred outcome (the unique EME profile). For example, an institution wants to create more engineering leaders, or EMEs. With this as a goal, they can use the TTI survey as a means to measure their progress. This research provides a specific metric to define that goal. Government studies, academic journals, and professional societies have recognized the need for engineering education reform to create better engineers; this survey will provide reformers with a useful tool to specifically measure progress toward that goal.

Longitudinal studies of student data can be performed to show measured progress toward achievement of a better engineer. For example, an institution can require all incoming freshmen to take the TTI survey. Analysis of the data may show that students generally score low in the leadership skill. The institution can then review curricula and extra-curricular activities to incorporate opportunities for students to practice leadership skills. The following year, the sophomore class can re-take the TTI survey to determine if the leadership skill scores have changed. These scores will provide a feedback mechanism to the institution to measure, track, and improve engineering programs. Figure 11 illustrates how the system interacts with the measurement system (TTI survey) and how feedback can be integrated into the system to continuously improve performance. The TTI survey results provide numeric data; therefore, incremental changes can be shown and tested to determine statistically significant differences. These studies will also serve as evidence in an institution's program for tracking and improving student outcomes, which will be useful in the accreditation process.

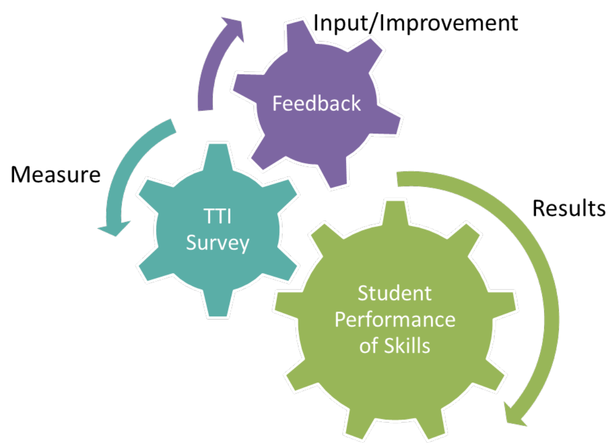


Figure 11. Student Improvement System

In addition to tracking student performance, with this unique profile of an EME, more practitioners can take the TTI survey, and those individuals can be categorized as a non-EME or EME. This research shows a distinct difference; therefore, the profile of an EME can be used to differentiate the engineer into either the non-EME or EME group. This can be useful to researchers or employers who want to identify an engineer who exemplifies an EME. Adding data to the existing database will strengthen the results.

Engineering education has recognized the need to change in order to create engineers who will be able to solve problems of the future that are not even defined today. Therefore, continuous learning and the ability to see society's future needs are paramount in the ability of an engineer to contribute to the country's well-being. Engineering will continue to have a strong foundation in technical fundamentals, yet reformers realize that additional skills such as leadership and communication are necessary to meet the demands of the future.

Recommendations

Additional research has already begun. These data, along with student data, are being used to develop a structural equation model (Pistrui, Layer & Dietrich, 2012). This model is used to determine what characteristics are significant and the relationship between the behaviors, values, and skills of the groups measured. This model will be updated and refined with the data from this research and subsequent data to be collected. These data will also be compared to high performing individual levels in a national sample of data already collected. These comparisons will offer additional insights as to how engineers can compare with other industries and professions.

There are many constructive directions for further research based on these results. These results can be compared to a population of strictly entrepreneurs, a normal population, or student data. The TTI Performance DNA™ survey results from these populations can be compared directly using these data as distinct groups. As shown above, the profile of an EME is different from the profile of an entrepreneur when considering behaviors and professional skills. This survey can define specific professional skills unique to each group. This can detail how engineering entrepreneurs are different from a normal population of entrepreneurs. The data can also be compared to a normal population. Practitioners from various fields may be different from the engineers or specifically EMEs. These differences can provide insight into characteristics that make engineers unique or explain how they differ from a normal population or other industry groups. Finally, student data can be compared to the practitioner data to help guide various curricular and co-curricular activities that are offered to students in providing opportunities for the students to master various professional skills.

The implication of understanding the entrepreneurially-minded engineer is important for engineering education. The marketplace demand for technical leaders is growing, and companies appreciate these EME skills. With an understanding of how to differentiate EMEs, universities can highlight both curricular and co-curricular activities to provide students with a chance to practice and develop mastery of these skills. The top professional skills that differentiate EMEs provide universities with a roadmap for program development, curriculum enhancement, and assistance in the accreditation process.

Continuing research in different cultural areas would also be a useful comparison for these results. There may be differences in the students and engineers from China and India, for example. As the United States tries to remain competitive with these nations, this understanding would be a useful benchmarking tool. There may also be a difference in foreign students who attend college in the United States. This demographic should be considered when measuring student data further. In addition to cultural differences, there may be differences in male and female respondents. If there are, this may help engineering education institutions recruit males or females using varying techniques. If the profile of a female engineer is different from that of a male engineer, there may be opportunities to make program adjustments that appeal to one group over another. In this study, comparing EMEs and non-EMEs did not show a significant difference in values; however, values may be significant when comparing cultures or male/female.

Another demographic not studied here is engineering degree area of concentration. It may be helpful to understand if there are differences among mechanical, chemical, or industrial engineers. These differences can be considered in the individual program curricula for the areas of concentration. New degree programs based on changing technology, such as nanotechnology, have been developed. It may be helpful to understand if these new programs attract a different type of engineer. With that understanding, specific actions can be taken to recruit students to those new programs and keep them interested in the area of study. Student retention is an important measure for universities.

Summary

The use of the TTI Performance DNA™ survey is helping define the vision of the next generation engineer by using analytical results to help participating universities measure program effectiveness. This research is a specific part of the analytical definition and will provide direction for university programming to create more entrepreneurially-minded engineers. This research reveals that there is a difference between practicing engineers and engineering leadership in terms of professional skills; therefore, a specific profile can be established for these two groups. This profile can be used by engineering education institutions as a benchmark goal for their students. It can also be used to refine program changes that will allow students to develop skills that specifically define an EME. For example, one of the distinguishing characteristics of an EME was found to be persuasion. Institutions could develop opportunities for students to debate various ideas. This would help students practice their ability to persuade others.

This research has shown that the construct validity of the TTI Performance DNA™ survey is adequate to discern the difference between engineers and entrepreneurially-minded engineers using two of the four behaviors and 12 of the 23 professional skills. This difference was not seen when considering time on the job or whether participants had a graduate degree. It was only significant when comparing the two groups of engineers. Therefore, the use of the survey behaviors and professional skills is one way to measure characteristics of practitioners and serve as a benchmark for students. The research provided statistical testing of the data to examine the construct validity.

This research also provides a foundation for further study. Using the TTI survey, other groups of individuals, such as other practitioners and entrepreneurs, can be assessed. Student data that have already been collected can be used as a benchmark as well. Further, the specific profiles of each of these groups can be compared. Other indicators such as cultural background, sex, and area of degree concentration can be used to look for differences. Engineering education institutions can use the survey data to compare student groups and cross-institution programs. Further, engineering practitioners can use the survey as a professional development tool and team development exercise. This survey and data analysis provides a strong foundation for further research that supports the creation of better engineers to keep the American economy strong and prosperous.

References

ABET. (2011). Criteria for Accrediting Engineering Programs, 2012 - 2013. Retrieved December 4, 2011, from Accreditation Board for Engineering and Technology: http://www.abet.org/engineering-criteria-2012-2013/

About Us, LinkedIn. (2011). Retrieved November 9, 2011, from LinkedIn: http://press.linkedin.com/about

American Society for Engineering Education. (2012). *Innovation with impact*, June 1, 2012, Washington, DC: ASEE.

Atkinson, R. C., &. Pelfrey, P. A. (2010). Science and the entrepreneurial university. *Issues in Science and Technology*, *Summer, 2010,* 39-48.

Baumol, W. J., Schilling, M. A., & Wolfe, E. N. (2009). The superstar inventors and entrepreneurs: how were they educated? *Journal of Economics & Management Strategy, 18*(3), 711-728.

Bjorklund, S. A., & Colbeck, C. L. (2001, January). The view from the top: leadership perspectives on a decade of change in engineering education. *Journal of Engineering Education*, 13-19.

Blessing, J., Mekemson, K., & Pistrui, D. (2008). Building an entrepreneurial engineering ecosystem for future generations: the Kern Entrepreneurship Education Network. Proceedings from *American Society for Engineering Education Annual Conference*. Pittsburgh, PA: ASEE.

Blizzard, J., Klotz, L., Pradhan, A., & Dukes, M. (2012). Introducing whole-systems design to first-year engineering students with case studies. *International Journal of Sustainability in Higher Education, 13*(2), 177 - 196.

Bonnstetter, B. J., Bonnstetter, R. J., & Preston, D. (2010, May 14). *Do you have what it takes to be a successful engineering student?* Scottsdale, AZ: Target Training, International, Ltd.

Bonnstetter, R. J., Bonnstetter, B. J., & Preston, D. (2010). *Do you have what it takes to be a serial entrepreneur?* Scottsdale, AZ: Target Training International, Ltd.

Bonnstetter, B. J., & Suiter, J. I. (2011). *The TTI motivators: a reference manual*. Scottsdale, AZ: Target Training International, Ltd.

Bonnstetter, B. J., & Suiter, J. I. (2011). *The universal language DISC reference manual*. Phoenix, AZ: Target Training International, Ltd.

Bordogna, J., Fromm, E., & Ernst, E. (1993). Engineering education: Innovation through integration. *Journal of Engineering Education,* 3-8.

Borrego, M., Douglas, E.P., & Amelink, C. T. (2009, January). Quantitative, qualitative and mixed research methods in engineering education. *Journal of Engineering Education*, 53-66.

Bull, I., & Willard, G. E. (1993). Towards a theory of entrepreneurship. *Journal of Business Venturing,* 8, 183-195.

Burns, A. T., Acar, W., & Datta, P. (2011). A qualitative exploration of entrepreneurial knowledge transfers. *Journal of Knowledge Management, 15*(2), 270-298.

Carlino, G., Hunt, R., Duranton, G., & Weinburg, B.A. (2009). What explains the quantity and quality of local inventive activity? Philadelphia, PA: *Brookings-Wharton Papers on Urban Affairs*, 65-123.

Carrier, C. (1996). Intrapreneurship in small businesses: an exploratory study. *Entrepreneurship: Theory and Practice, 21*(1), 5-20.

Clouse, R. W., & Aniello, J. (2007). Learning in Action! (LIA): A problem-based learning experience for developing the entrepreneurial spirit. Proceedings from *American Society for Engineering Education*. Honolulu, HI: ASEE.

Colombo, M., Mustar, P., & Wright, M. (2010). Dynamics of science-based entrepreneurship. *Journal of Technology Transfer, 35,* 1-15.

Companys, Y. E., & McMullen, J. S. (2007). Strategic entrepreneurs at work: the nature, discovery and exploitation of entrepreneurial opportunities. *Small Business Economics, 28*(4), 301-322.

Condoor, S., & McQuilling, M. (2009). Incorporating an entrepreneurial mindset in freshmen engineering students. Proceedings from *American Society for Engineering Education Annual Conference*. Austin, TX: ASEE.

Corporate ventures need to be guided by 'intrapreneurs'. (1982, November 12). *Marketing News*, pp. 12-13.

Crawford, P., Lang, S., Fink, W., Dalton, R., & Fielitz, L. (2011, August 4). Comparative analysis of soft skills: what is important for new graduates? East Lansing, MI: *Michigan State University College of Agriculture and Natural Resources*.

Cronbach, L. J. (1951). Coefficient Alpha and the Internal Structure of Tests. *Psychometrika, 16*(3), 297-334.

Davis, D., & Rose, J. (2007). Entrepreneurial engineering capstone course with research-based outcomes assessment. Proceedings from *American Society for Engineering Education Annual Conference.* Honolulu, HI: ASEE.

Dubina, I., Carayannis, E. G., & Campbell, D. F. J. (2012). Creativity economy and a crisis of the economy? Coevolution of knowledge, innovation and creativity and of the knowledge economy and knowledge society. *Journal of Knowledge Economics, 3*, 1 - 24.

Eifert, J. R. (1998). Responding to a Changing World: 21s' Century Curricula at Rose-Hulman Institute of Technology. Proceedings from *Engineering Foundation Conference*, New York, NY.

Engler, R. C., & Ribeiro, T. M. (2008). Innovation and entrepreneurship: major tools for designers. Proceedings from *Industrial Engineering Research Conference*, Vancouver, BC: IIE, 1480-1485.

Eseounu, C. I., Wyrick, D. A., & Vaccari, E. (2010). Empowering technological entrepreneurs: developing a framework for technical business development. Proceedings from *Industrial Engineering Research Conference*. Cancun, Mexico: IIE.

Faley, T., & Adriaens, P. (2008). Developing a joint engineering/business school entrepreneurial curriculum. Proceedings from *American Society for Engineering Education*. Pittsburgh, PA: ASEE.

Forrester, J. W. (1967). Engineering education and engineering practice in the 21^{st} century. *National Academy of Engineering*.

Fry, C. C., Jordan, W. M., Dougherty, E. J., Rayess, N. E., Singh, P., & Bloemer, K. F. (2012). The helping hands dense network: A collaboration across multiple universities. Proceedings from *American Society for Engineering Education Annual Conference*. San Antonio, TX: ASEE.

Fry, C., & Pistrui, D. (2011). Assessing the entrepreneurial mindset within engineering programs. Proceedings from *American Society for Engineering Education Annual Conference*. Vancouver, BC: ASEE.

García-Morales, V. J., Matias-Reche, F., & Verdu-Jover, A. J. (2011). Influence of internal communication on technological proactivity, organizational learning, and organizational innovation in the pharmaceutical sector. *Journal of Communication, 61*, 150–177.

Grayson, L. (1977, December). A brief history of engineering education in the United States. *Engineering Education*, 246-264.

Gross, W. A. (2000, April 8). Entrepreneurship education. Proceedings from *Technological Education and National Development Conference*, Abu Dhabi, United Arab Emirates: EDRS.

Haltiwanger, J. (2012, January). Job Creation and Firm Dynamics in the United States. *Innovation Policy and the Economy,12*(1), 17-38.

Harkema, S. J. M., & Schout, H. (2008). Incorporating student-centered learning in innovation and entrepreneurship education. *European Journal of Education, 43*(4), 513-526.

Harris, K. (1995). Collected Quotes from Albert Einstein. Retrieved December 4, 2011, from http://rescomp.stanford.edu/~cheshire/EinsteinQuotes.html

Hart, D. M., & Acs, Z. J. (2011). High-tech immigrant entrepreneurship in the United States. *Economic Development Quarterly, 25*(2), 116-129.

Hartog, J., vanPraag, M., & van der Sluis, J. (2010). If you are so smart, why aren't you an entrepreneur? *Journal of Economics & Management, 19*(4), 947-989.

Hsu, D. H., Roberts, E. B., & Eesley, C. E. (2007). Entrepreneurs from technology-based universities: evidence from MIT. *Research Policy, 36*, 768-788.

IBM. (2008, 5 8). 2008 Global CEO Study: Enterprise of the Future. Retrieved December 3, 2011, from IBM: http://www.ibm.com/ibm/ideasfromibm/us/ceo/20080505/

Karanian, B. (2007). Entrepreneurial leadership and transformational change. Proceedings from *American Society for Engineering Education Annual Conference*. Honolulu, HI: ASEE.

Kelly, W. (2008). Does active learning promote understanding and entrepreneurial tendencies? Proceedings from *American Society for Engineering Education Annual Conference*. Pittsburgh, PA: ASEE.

Kern Family Foundation. (2011). Kern Entrepreneurship Education Network (KEEN). Retrieved November 1, 2011, from Kern Family Foundation: http://www.kffdn.org/default.asp?L1=InnovationPrograms&L2=KEEN

Kern, R. D. (2012). Innovation Programs. Retrieved May 6, 2012, from Kern Family Foundation: http://www.kffdn.org/default.asp?L1=InnovationPrograms

Ko, S., & Butler, J. E. (2010). A key link to entrepreneurial behavior. *Business Horizons, 50*, 365-372.

Koro-Ljungeburg, M., & Douglas, E. P. (2008, April). State of qualitative research in engineering education: Meta-analysis of JEE articles 2005 - 2006. *Journal of Engineering Education*, 163-175.

Kranzberg, M. (2006). Confrontation or Complementarity? : Perspectives on Technology and the Arts. *Annals of the New York Academy of Sciences*.

Kriewall, T., & Mekemson, K. (2010). Instilling the entrepreneurial mindset into engineering undergraduates. *Journal of Engineering Entrepreneurship*, *1*(1), 5-19.

Lazear, E. M. (2002). Entrepreneurship. NBER Working Paper No. 9109.

Lentz, R. & Mortensen, D. T. (2008). An empirical model of growth through product innovation. *Econometrica, 76*(6), 1317-1373.

Lewin, A. Y., Massini, S., & Peeters, C. (2009). Why are companies offshoring innovation? The emerging global race for talent. *Journal of International Business Studies, 40*, 901-925.

Low, M. B., & MacMillan, I. C. (1988, June). Entrepreneurship: Past reserach and future challenges. *Journal of Management, 14*(2)139-161.

Margari, F., Matarazzo, R., Casacchia, M, Roncone, R., Dieci, M., Safran, S., Fiori, G., Simoni, L., & the EPICA study group (2005). Italian validation of MOAS and NOISE: a useful package for psychiatric assessment and monitoring of aggressive behaviours. *International Journal of Methods in Psychiatric Research, 14*(2), 109-118.

Marshall, S. P. (2010). Re-imagining specialized STEM academics: igniting and nurturing decidedly different minds, by design. *Roeper Review, 32*(1), 48-60.

Marston, W. M. (1928). Emotions of normal people. New York, NY: Harcourt, Brace and Company.

Mason, T. (2008). Impacts of entrepreneurship centers and programs on the preparation of entrepreneurial engineers. Proceedings from *American Society for Engineering Education Annual Conference*. Pittsburgh, PA: ASEE.

Mathews, J. A., & Zander, I. (2007, May). The international entrepreneurial dynamics of accelerated internationalization. *Journal of International Business Studies, 38*(3), 387-403.

Menzel, H. C., Aaltio, I., & Ulijn, J. M. (2007). On the way to creativity: engineers as intrapreneurs in organizations. *Technovation, 27*, 732-743.

Minder, E. I., Schneider-Yin, X., & Minder, C. E. (2010). Patient-recorded outcome to assess therapeutic efficacy in protoporphyria-induced dermal phototoxicity: a proposal. *Health and Quality of Life Outcomes, 8*(60), 1-13.

Mueller, P. (2007). Exploiting entrepreneurial opportunities: the impact on growth. *Small Business Economics, 28*(4), 355-62.

Mukoyama, T. (2004). Diffusion and Innovation of New Technologies under Skill Heterogeneity. *Journal of Economic Growth, 9*(4), 451-479.

Mulder, K. (2006). Engineering curricula in sustainable development. An evaluation of changes at Delft University of Technology. *European Journal of Engineering Education, 31*(2), 133-144.

The National Academy of Sciences. (2005). *Educating the engineer of 2020: Adapting engineering education to the new century.* Washington, DC: The National Academies Press.

The National Academy of Sciences, The National Academy of Engineering, and The Institute of Medicine. (2006). *Rising above the gathering storm*. Washington, DC: The National Academies Press.

Nunnally, J. (1978). *Psychometric Theory*. New York: McGraw-Hill.

Pisano, G. P., & Shih, W. C. (2009). Restoring American competitiveness. *The Harvard Business Review*, 1-13.

Pistrui, D., Layer, J., & Dietrich, S. (2012). Mapping the behaviors, motives and professional competencies of entrepreneurially minded engineers in theory and practice: an empirical investigation. Proceedings from *American Society for Engineering Education Annual Conference*. San Antonio, TX: ASEE

Pistrui, D., & Fry, C. C. (2011). Assessing the mindset within engineering programs across the Kern Entrepreneurship Education Network. Proceedings from *American Society for Engineering Education Annual Conference*. Vancouver, BC: ASEE.

Pistrui, D. (2003). *Growth intentions and expansion plans of new entrepreneurs in transforming economies: An investigation into family dynamics, entrepreneurship, and enterprise development*. (unpublished doctoral dissertation). Barcelona, Spain: Universitat Autonoma de Barcelona .

Pistrui, D. (2007, May 18). Innovate now: report on innovation. Chicago, IL: Illinois Institute of Technology.

Prados, J. W. (1998). Engineering education in the United States: Past, present and future. Proceedings from *International Conference on Engineering Education*. Rio de Janeiro, Brazil: ICEE-98.

Reid, P. M. (2009). Open innovation: an evolving entrepreneurship technique. *International Review of Entrepreneurship, 7*(1), 81-94.

Reimer, D., & Pierce, M. (2010). Engineering entrepreneurship internship programs: planning, operating and growing. Proceedings from *American Society for Engineering Education Annual Conference*. Louisville, TN: ASEE.

Reimer, D., Ali, A., & Abro, S. R. (2011). Relationship between student competitive activities and entrepreneurial mindset. Proceedings from American *Society for Engineering Education Annual Conference*. Vancouver, BC: ASEE.

Richardson, I., & Hynes, B. (2008). Entrepreneurship education: towards an industry sector approach. *Education and Training, 50*(3), 188-198.

Roman, H. T. (2004). Blame it on the engineers. *The Technology Teacher, 63*, 21-23.

Sanders, M. (2007, April). Scientific paradigms, entrepreneurial opportunities and cycles in economic growth. *Small Business Economics, 28*(4), 339-354.

Schumpeter, J. A. (1935). The Analysis of Economic Change. *The Review of Economics and Statistics, 17*(4), 2-10.

Seely, B. (2005). Patterns in the history of engineering education reform: A brief essay. *Educating the engineer of 2020: Adapting engineering education to the new century*. Washington, DC: National Academies Press, 114 – 130.

Shane, S. (2001, February). Technological opportunities and new firm creation. *Management Science, 47*(2), 205-220.

Shuman, L. J., Besterfield-Sacre, M., & McGourty, J. (2005, January). The ABET "professional skills" - can they be taught? *Journal of Engineering Education*, 41-55.

Silva, A., Henriques, E., & Carvalho, A. (2009). Creativity enhancement in a product development course through entrepreneurship learning and intellectually property awareness. *European Journal of Engineering Education, 34*(1), 63-75.

Smith-Nightingale, D. (2010, December). What are future prospects for America's poor today? *Social Service Review, 84*(4), 679-683.

Spranger, E. (1928). Types of men. (P. W. Pigors, Trans.). New York, NY: Johnson Reprint Corporation.

Target Training International, Ltd. (2011). *TTI Performance DNA Coaching Report*. Scottsdale, AZ: TTI, Ltd.

Teddlie, C., & Yu, F. (2007, January). Mixed methods sampling: a typology with examples. *Journal of Mixed Methods Research, 1*(1), 77-100.

Timmons, J. (1994). *New Venture Creation*. Chicago, IL: Irwin.

Tribus, M. (2005, March). Some remarks on the improvement of engineering education. *Journal of Science and Technology, 14*(1), 1-28.

U.S. Patent and Trademark Office. (2011). *Extended Year Set - All Technologies (Utility Patents) Report*. Retrieved December 3, 2011, from U.S. Patent and Trademark Office: http://www.uspto.gov/web/offices/ac/ido/oeip/taf/h_at.htm#Desc

vanStel, A., Carree, M., & Thurik, R. (2005). The effect of entrepreneurial activity on national economic growth. *Small Business Economics, 24*(3), 311-321.

Wadhwa, V. (2009). A reverse brain drain. *Issues in Science and Technology*, Spring, 2009, 45-52.

Wadhwa, V. (2012, January/February). Think Small. *Foreign Policy*, 68.

Warner, S. A. (2009). The soul of technology education: Being human in an overly rational world. *Journal of Technology Education, 21*(1), 72-86.

Weber, K. M., & Rohracher, H. (2012). Legitimizing research, technology and innovation policies for transformative change. *Research Policy, 41*, 1037– 1047.

Wennekers, S., & Thurik, R. (1999, August). Linking entrepreneurship and economic growth. *Small Business Economics, 13*(1), 27-55.

Westfall, S. L. (1969, June). Stimulating corporate entrepreneurship in US industry. *The Academy of Management Journal, 12*(2), 235-246.

Wirasinghe, C. (2000). Engineering education for leadership in the 21st century. Proceedings from *Technological Education and National Development Conference*. Abu Dhabi, United Arab Emirates.

APPENDIX A: Human Subjects Approval

EASTERN MICHIGAN UNIVERSITY
Education First

UHSRC Initial
Application Determination
EXEMPT APPROVAL

June 7, 2011

To: Sandra Dietrich
College of Technology

Re: **UHSRC # 110508** Category: EXEMPT #2 and #4
Approval Date: June 3, 2011

Title: "Quantifying Entrepreneurial Minded Engineers"

The Eastern Michigan University Human Subjects Review Committee (UHSRC) has completed their review of your project. I am pleased to advise you that **your research has been deemed as exempt** in accordance with federal regulations.

The UHSRC has found that your research project meets the criteria for exempt status and the criteria for the protection of human subjects in exempt research. **Under our exempt policy the Principal Investigator assumes the responsibility for the protection of human subjects** in this project as outlined in the assurance letter and exempt educational material.

Renewals: Exempt protocols do not need to be renewed. If the project is completed, please submit the **Human Subjects Study Completion Form** (found on the UHSRC website).

Revisions: Exempt protocols do not require revisions. However, if changes are made to a protocol that may no longer meet the exempt criteria, a **Human Subjects Minor Modification Form** or new **Human Subjects Approval Request Form** (if major changes) will be required (see UHSRC website for forms).

Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events, or any problem that may increase the risk to human subjects and change the category of review, notify the UHSRC office within 24 hours. Any complaints from participants regarding the risk and benefits of the project must be reported to the UHSRC.

Follow-up: If your exempt project is not completed and closed after three years, the UHSRC office will contact you regarding the status of the project and to verify that no changes have occurred that may affect exempt status.

Please use the UHSRC number listed above on any forms submitted that relate to this project, or on any correspondence with the UHSRC office.

Good luck in your research. If we can be of further assistance, please contact us at 734-487-0042 or via e-mail at human.subjects@emich.edu. Thank you for your cooperation.

Sincerely,

Deb de Laski-Smith

Deb de Laski-Smith, Ph.D.
Interim Dean
Graduate School
Administrative Co-Chair
University Human Subjects Review Committee

University Human Subjects Review Committee · Eastern Michigan University · 200 Boone Hall
Ypsilanti, Michigan 48197
Phone: 734.487.0042 Fax: 734.487.0050
E-mail: human.subjects@emich.edu
www.ord.emich.edu (see Federal Compliance)

The EMU UHSRC complies with the Title 45 Code of Federal Regulations part 46 (45 CFR 46) under FWA00000050.

APPENDIX B: Informed Consent

Dear Prospective Participant:

I am doing my PhD research into defining characteristics of Entrepreneurially-Minded Engineers. I am asking you to take a brief survey in order to help define those qualities. There is a link at the end of this document, which will take you to the survey. At the end of the survey, you will receive comprehensive results. This report is yours to keep and reflect on. Please read the consent document below. Clicking on the link and taking the survey indicate your consent. If you would like a copy of this form for your records, please print it from this page. When you follow the link to the survey you will not return to this page.

I am also going to perform a focus group in order to gain more insight into the survey instrument. This activity should be approximately two hours. If you are interested in participating, please send me an email and I will inform you of dates/locations. I thank you for your valuable time.

Project Title: Defining the Characteristics of Entrepreneurial-Minded Engineers (EMEs)

Investigator: Sandra L. Dietrich, Eastern Michigan University

Purpose of the Study: The purpose of this research study is to gain a better understanding of entrepreneurial-minded engineers. The survey will help quantitatively define the characteristics of EMEs.

Procedure: You will be asked to complete a survey about your demographic information and various preference options. Upon completing the questionnaires, you will be given a duplicate copy of this informed consent, which includes follow-up contact information, if needed. The approximate total time to complete the survey should be about 20 - 30 minutes.

Confidentiality: Only a code number will identify your survey responses. The results will be stored separately from the consent form, which includes your name and any other identifying information. At no time will you name be associated with your responses to any survey questions.

Expected Risks: There are no foreseeable risks to you by completing this survey, as all results will be kept completely confidential.

Expected Benefits: Upon completion of the survey, you will be given a comprehensive, personal report describing your results. This report is for your personal use and understanding.

Voluntary Participation: Participation in this study is voluntary. You may choose not to participate. If you do decide to participate, you can change your mind at any time and withdraw from the study without negative consequences.

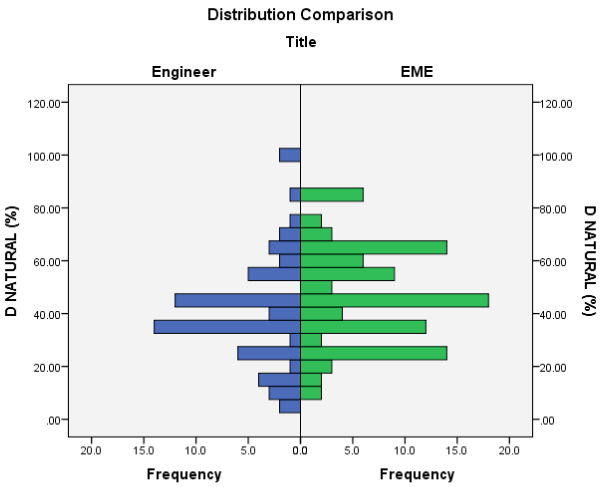
Use of Research Results: Results will be presented in aggregate form only. No names or individually identifying information will be revealed. Results may be presented at research meetings and conferences, in scientific publications, or as part of a doctoral dissertation being conducted by the principal investigator.

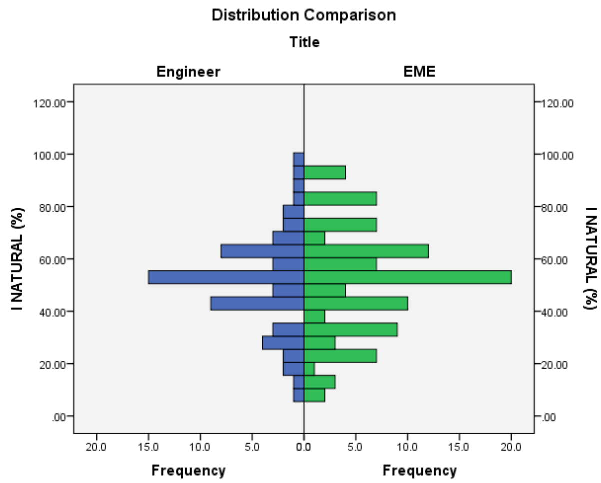
Future Questions: If you have any questions concerning your participation in this study now or in the future, you can contact the principal investigator, Sandra Dietrich, at 734-429-6392 or via e-mail sdietri1@emich.edu. This research protocol and informed consent document has been reviewed and approved by the Eastern Michigan University Human Subjects Review

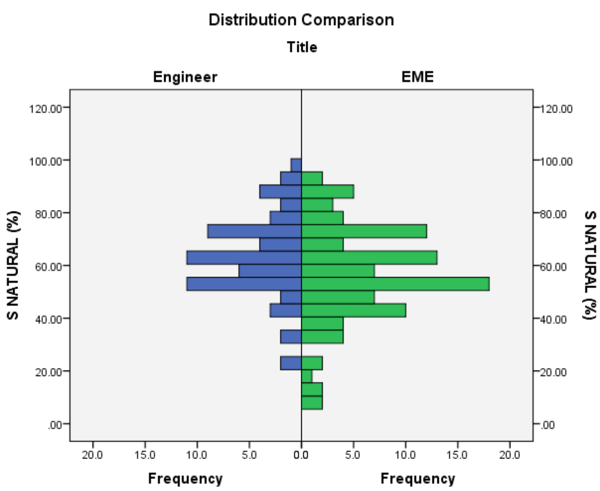
Committee for use from June 3, 2011to June 3, 2012. If you have questions about the approval process, please contact Dr. Deb de Laski-Smith (734.487.0042, Interim Dean of the Graduate School and Administrative Co-Chair of UHSCR, human.subjects@emich.edu).

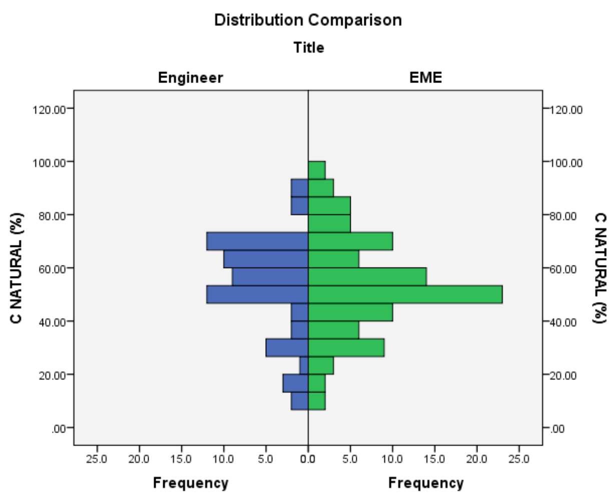
Consent to Participate: I have read or had read to me all of the above information about this research study, including the research procedures, possible risks, side effects, and the likelihood of any benefit to me. The content and meaning of this information has been explained and I understand. All my questions, at this time, have been answered. I hereby consent and do voluntarily offer to follow the study requirements and take part in the study. By following the link below, I agree to these terms.

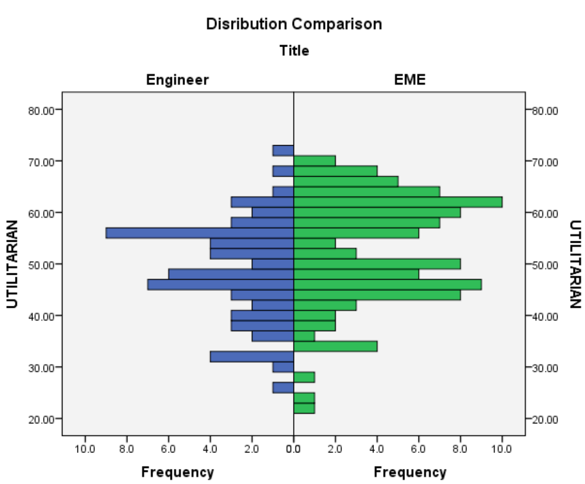
APPENDIX C: Data Set Distributions

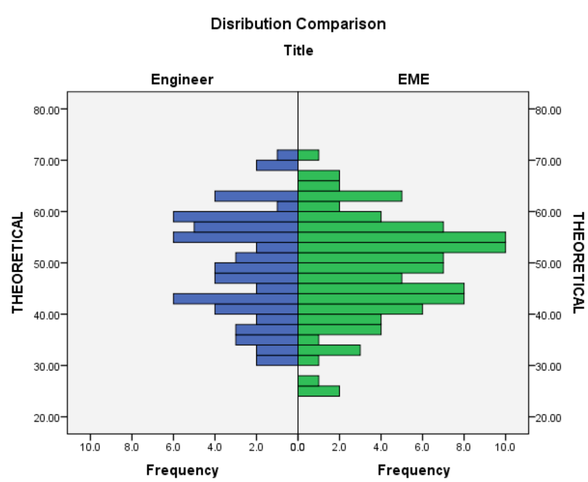


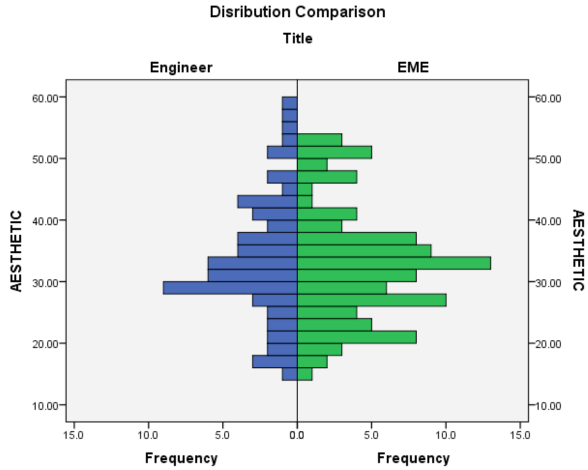








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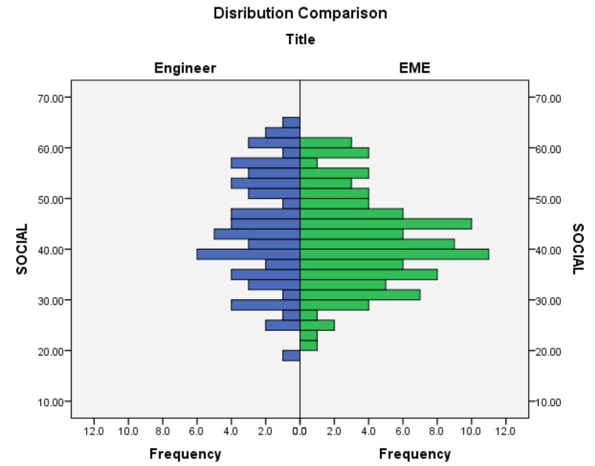
Title
Engineer
EME
AESTHETIC
AESTHETIC
Frequency
Frequency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Title
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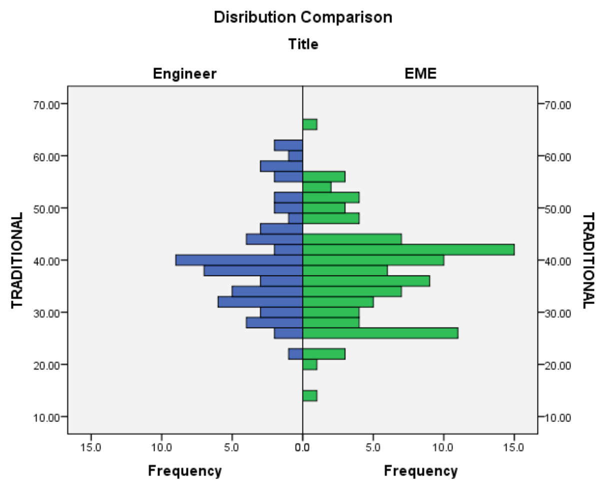
SOCIAL
Frequency
Frequency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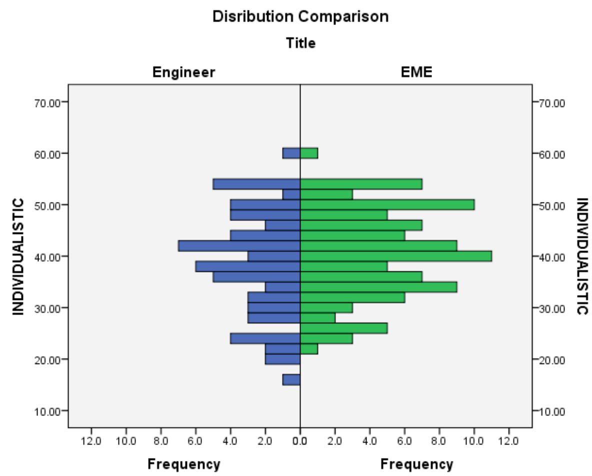
Frequency
Frequency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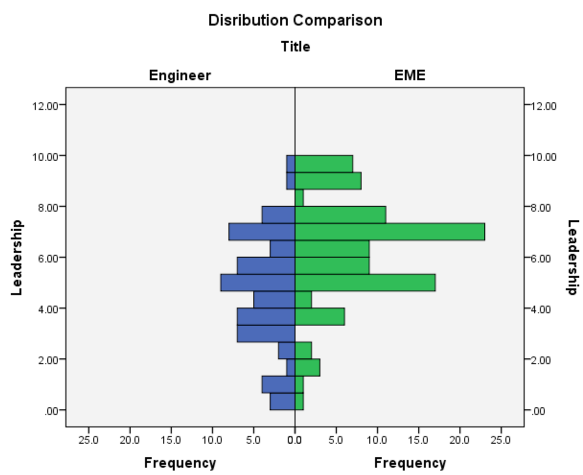
INDIVIDUALISTIC
INDIVIDUALISTIC
Frequency
Frequency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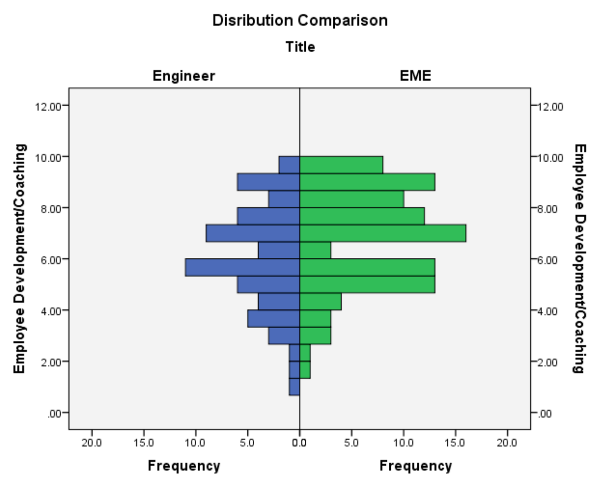
EME
Leadership
Leadership
Frequency
Frequency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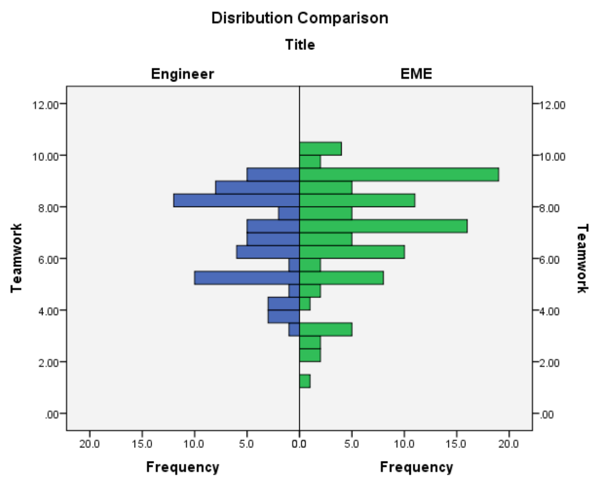
Engineer
EME
Employee Development/Coaching
Employee Development/Coaching
Frequency
Frequency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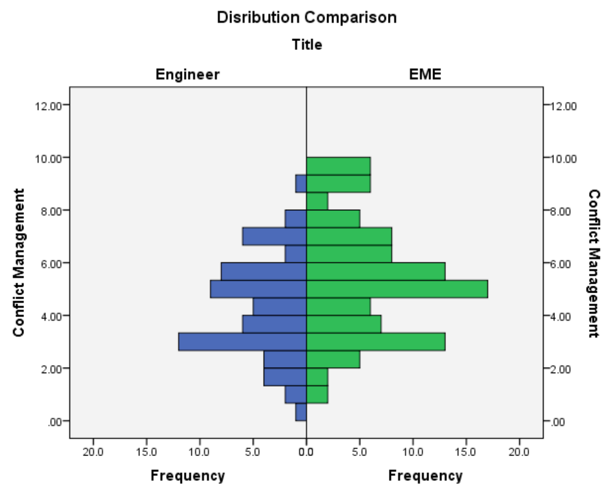
EME
Teamwork
Frequency
Frequency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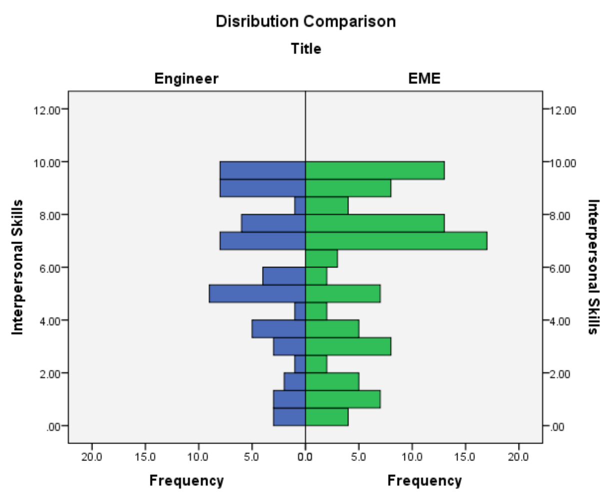
Frequency
Frequency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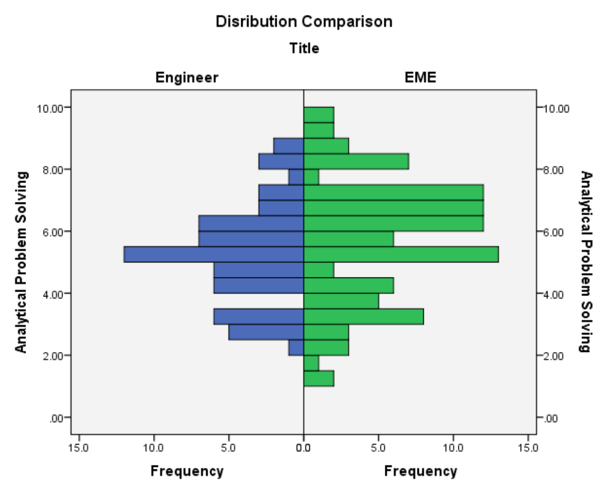
Interpersonal Skills
Frequency
Frequency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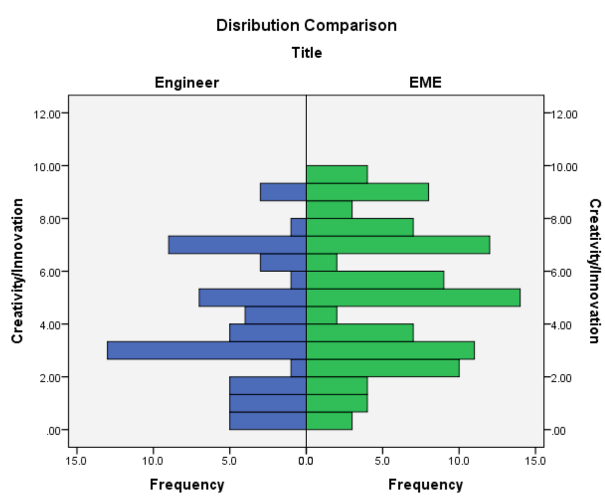
EME
Analytical Problem Solving
Frequency
Frequency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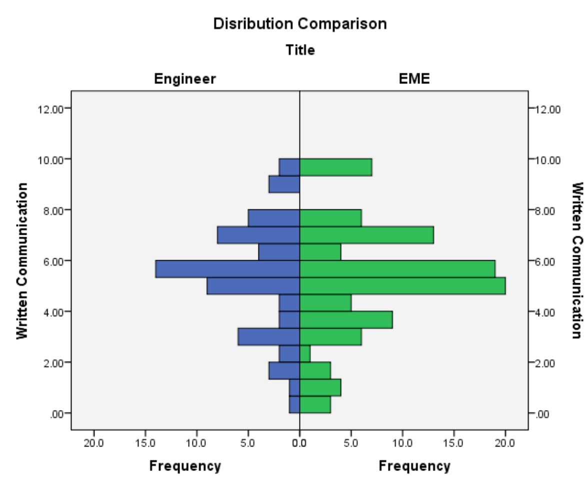
Engineer
EME
Creativity/Innovation
Frequency
Frequency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EME
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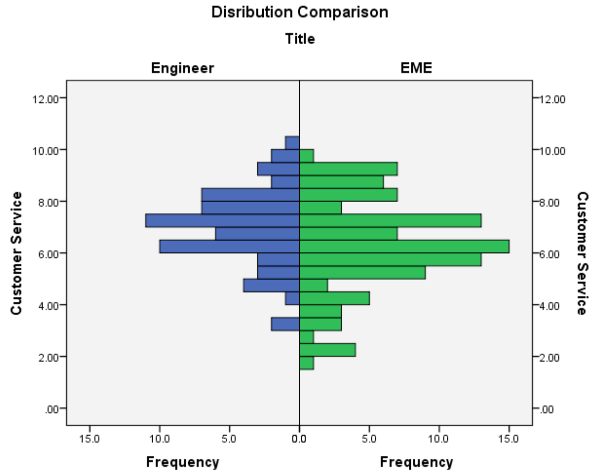
Frequency
Frequency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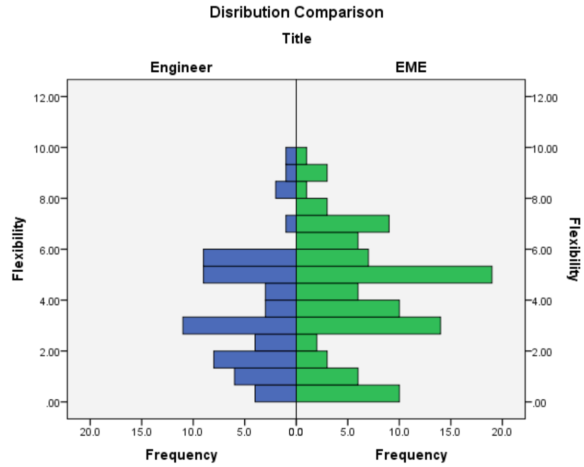
Customer Service
Customer Service
Frequency
Frequency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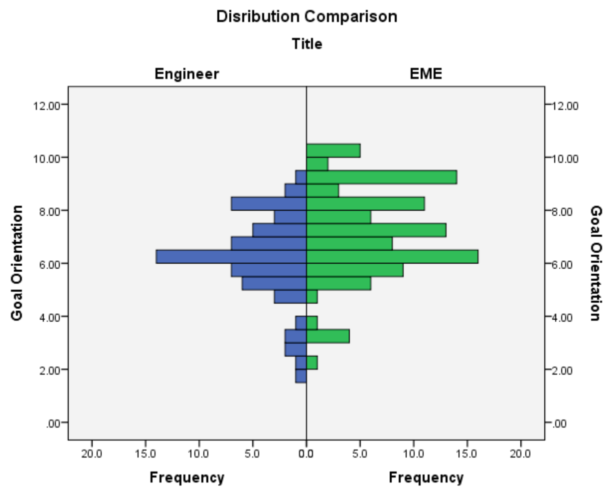
EME
Flexibility
Flexibility
Frequency
Frequency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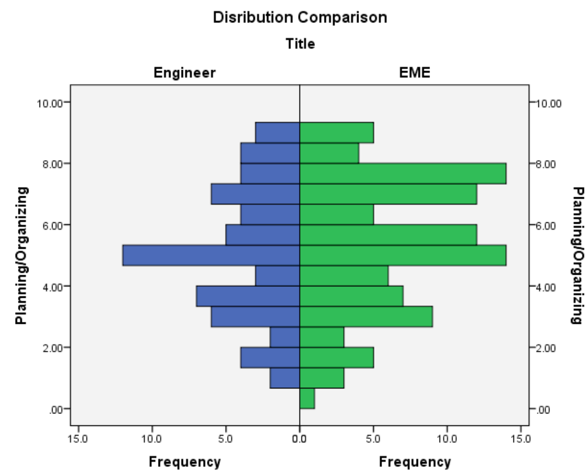
Engineer
EME
Goal Orientation
Goal Orientation
Frequency
Frequency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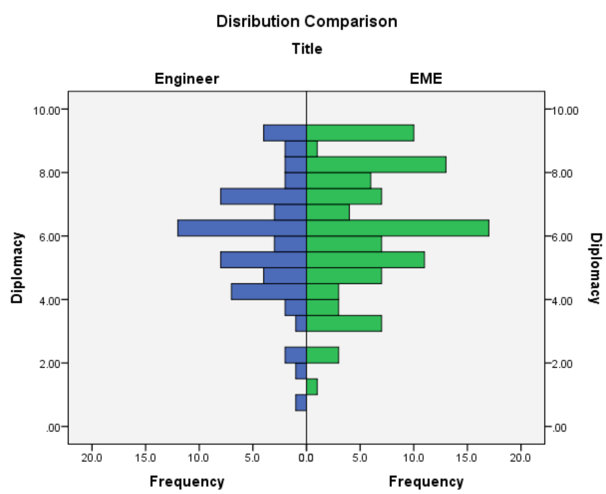
Title
Engineer
EME
Planning/Organizing
Planning/Organizing
Frequency
Frequency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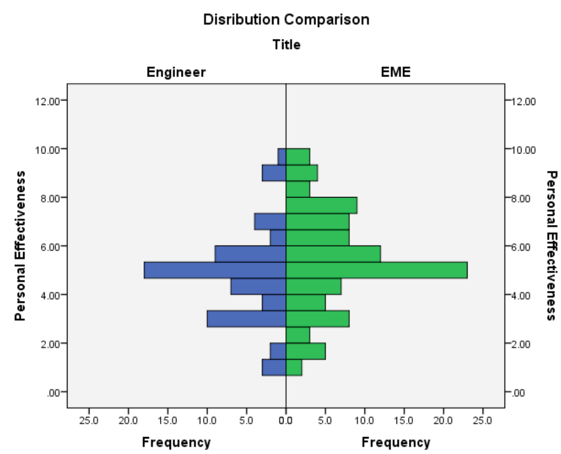
Engineer
EME
Diplomacy
Diplomacy
Frequency
Frequency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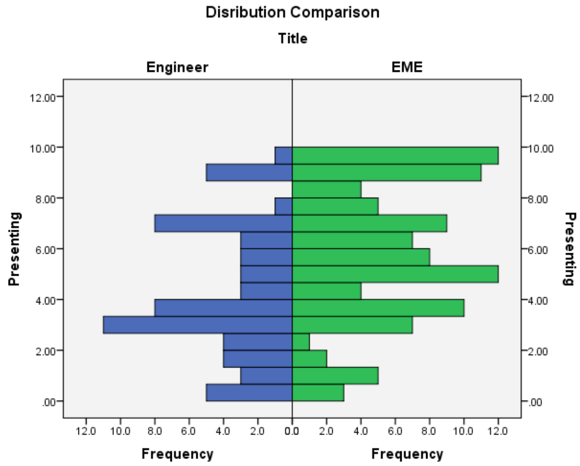
Engineer
EME
Personal Effectiveness
Personal Effectiveness
Frequency
Frequency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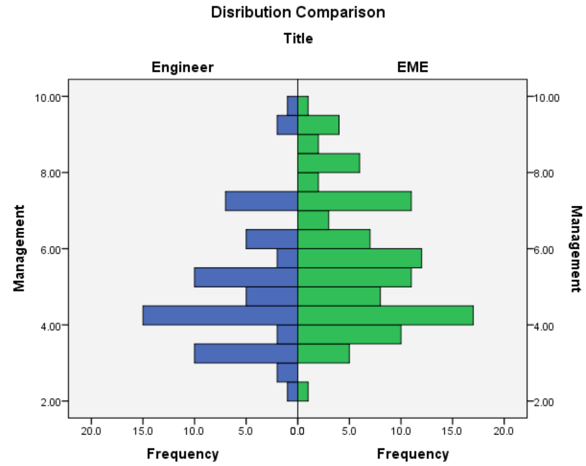
Engineer
EME
Presenting
Frequency
Frequency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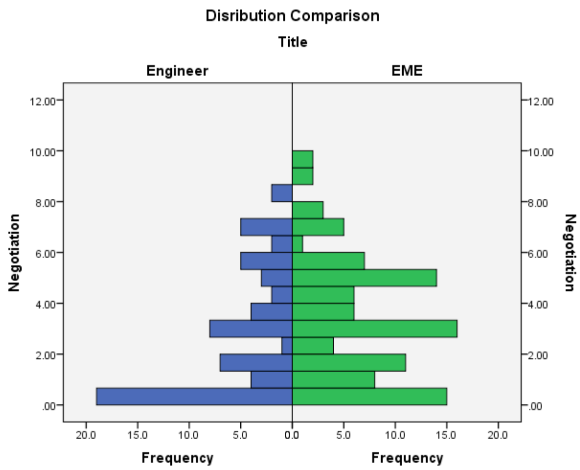
Engineer
EME
Management
Frequency
Frequency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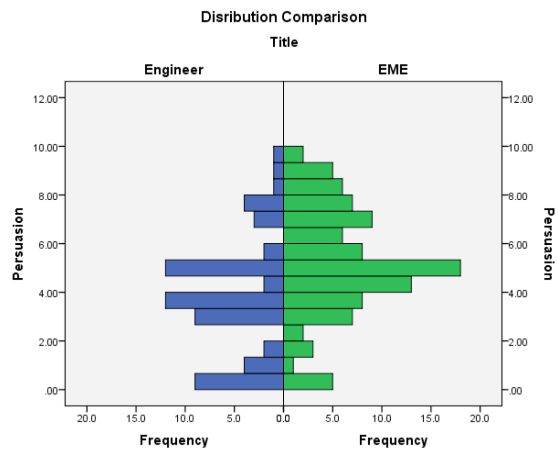
Engineer
EME
Negotiation
Frequency
Frequency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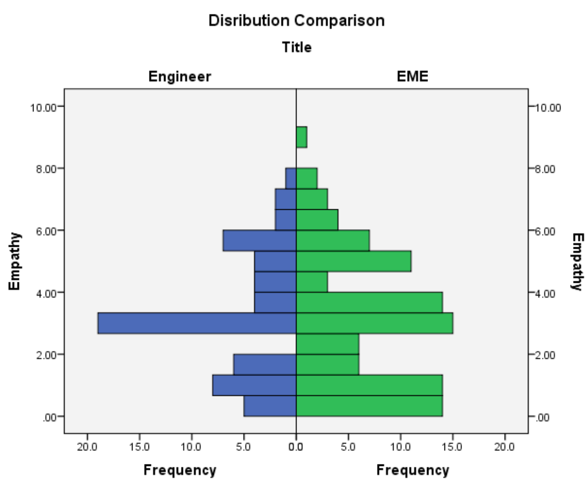
Engineer
EME
Persuasion
Frequency
Frequency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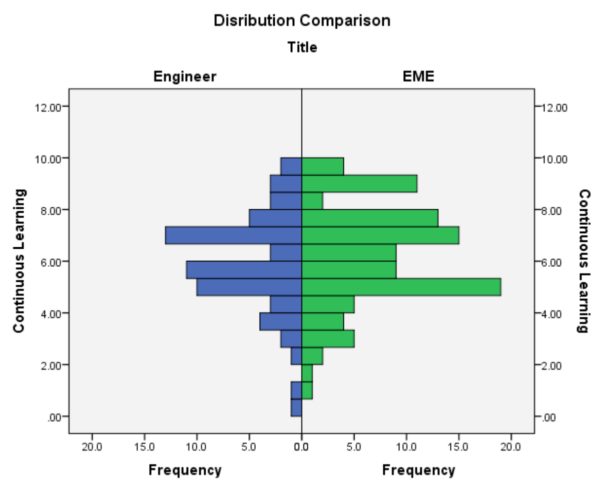
Frequency
Frequency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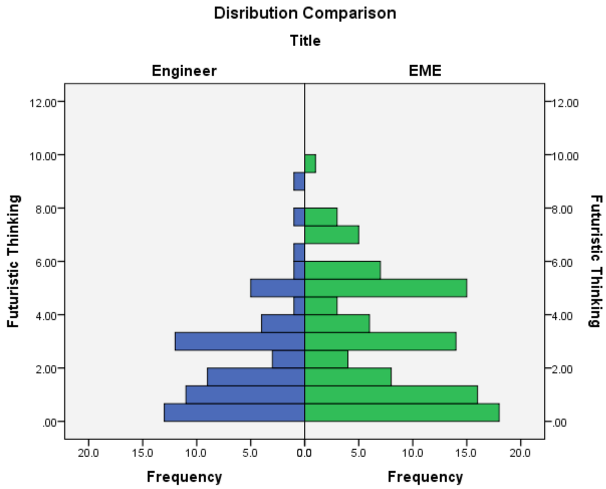
Engineer
EME
Continuous Learning
Frequency
Frequency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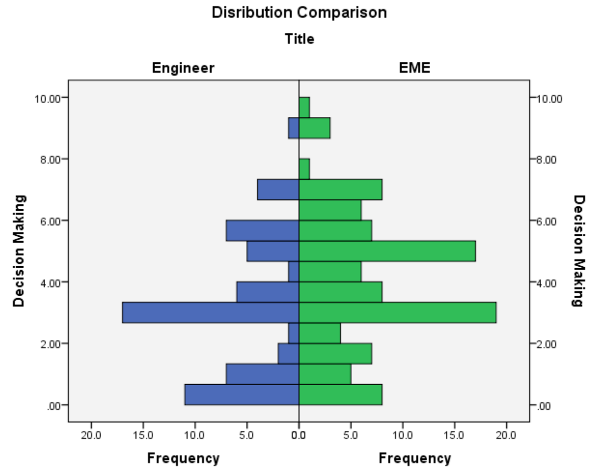
Engineer
EME
Futuristic Thinking
Frequency
Frequency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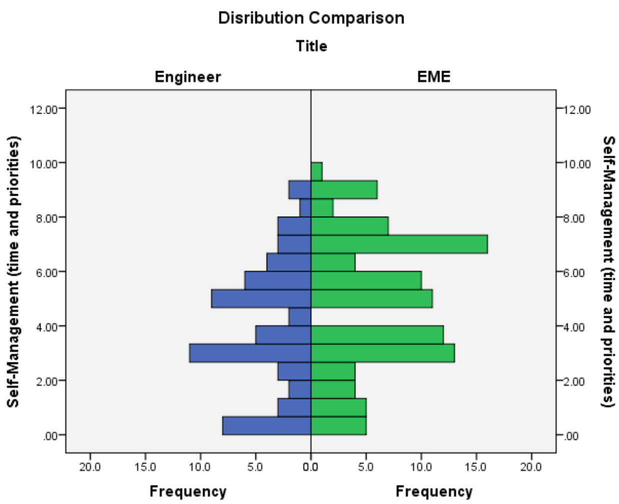
Engineer
EME
Decision Making
Frequency
Frequency


Disribution Comparison
Title
Engineer
EME
Self-Management (time and priorities)
Frequency
Frequency