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# Values of engineering majors : a step beyond Holland's model

Amanda Lynn Price
*University of Tennessee*

To the Graduate Council:

I am submitting herewith a dissertation written by Amanda Lynn Price entitled "Values of engineering majors : a step beyond Holland's model." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

Marla Peterson, Major Professor

We have read this dissertation and recommend its acceptance:

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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# Values of Engineering Majors: A Step Beyond Holland's Model

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Amanda Lynn Price
August 2002

## DEDICATION

This dissertation is dedicated to:

My mother, JEAN MARIE,

who gave me support, encouragement, and the gift of education.

Without her love and continued giving this degree would not be possible.

And to my husband, JAY PRICE,

who provided assistance and encouragement to get through all the details.

His compassion and love is appreciated more than he could ever know.

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Lastly, I appreciate my family's encouragement. My mother, husband, and in-laws have cheered me on during these years in school. Graduate school can be very trying, however, as I look at their smiling faces as I cross the finish line, I feel ready for my next endeavor. Thank you!

ABSTRACT

While reviewing previous research on the interests and values of engineering students, two themes emerged: (a) there is disagreement on whether interests and values are two separate constructs and (b) although there are studies that compare the interests and values of engineering majors and engineers to other majors and occupations, no studies have been found which focus on the relationship of interests and values within and among fields of engineering. The present study investigated the relationship between the Self-Directed Search, an interest inventory constructed on a model of six personality types, and the Values Scale, a values inventory, for students in different engineering fields.

One hundred and sixty-five undergraduate engineering students, 125 males and 39 females, at The University of Tennessee completed an assessment packet. The sample for the study included students from eleven engineering fields: Aerospace (n=5), Biomedical (n=11), Chemical (n=27), Civil (n=24), Computer (n=7), Electrical (n=26), Engineering Physics (n=2), Engineering Science (n=1), Industrial (n=29), Material Science and Engineering (n=5), and Mechanical (n=27).

Several significant results were found after investigating three research questions. The majority of the findings on the relationship between the personality types and values, were either expected or could be explained by examining the definitions of the values and applying them to the engineering sample. Gender differences were found regarding scores on the personality types and values factors. Males had higher scores on the Realistic and Investigative types and the Physical Prowess values factor, while females

had higher scores on the Conventional type. Those who participated in Cooperative Education had higher scores on the Conventional type while those students who did not had higher scores on the Realistic type and Physical Prowess values factor.

Some research on the relationship between personality types and specific engineering majors was confirmed in the present study. Results indicated that the Conventional type varied by major; yet, this result could not be adequately explored using the personality profiles listed for the engineering majors in *The College Majors Finder* (Rosen, Helmberg, & Holland, 1989). Finally, additional analyses highlighted the differences in scores on the personality types and values factors within engineering fields.

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# CHAPTER I

# INTRODUCTION

## Background and Theoretical Basis for the Study

John Holland's theory of vocational personalities and work environments states that vocational choice is an expression of personality, that personality can be measured through interest inventories, and that the congruence of personality and work environment is directly related to vocational satisfaction, stability, and achievement (Holland, 1997). Thus, his theory states and reports evidence that when deciding on a career, one needs to focus on knowledge of interests and work environments to make an appropriate occupational choice. Holland (1997) reports that other information, such as values inventories, typically does not discriminate efficiently between different vocational fields (Holland, Fritzsche, & Powell, 1994). Holland (1997) states that most of the studies on values have shown that occupations and values are moderately related and that values are related to interest areas in expected ways. It is also stated that "one can see that it is usually apparent that values and (interest) type go together" (Holland, Fritzsche, & Powell, 1994, p.37).

However, how does one help a student who is struggling to make an occupational choice between being a nuclear or a mechanical engineer? Both of these vocations have the same Holland code of IRE, thus they share similar interests and work environments. So now what does one focus on to help this individual? Holland says that there should be little vocational conflict for a person in this situation and that "other factors (e.g., lifestyle, capital requirements, and special aptitudes) may help him resolve the problem" (Holland, 1997, p.194). This statement means that there are times when knowing one's interests and the different vocations' work environments may not be enough. Lifestyle and capital requirements are considered values. Thus, Holland states that when interests are similar among vocations turning to other information such as knowledge about values may be important to help people resolve vocational conflicts.

Other career theorists believe that career decision making is a complex process. Super (1992) states that there is no simple process of matching people to occupations. Several things need to be taken into account such as needs, values, interests, and circumstances as well as the changes in the nature of work and the changes in people's lives. His model of career assessment and counseling is developmental in nature and states that using a variety of test instruments will give the counselor information about a client's career decision making status (Osborne, Brown, Niles, & Miner, 1997). Among his five assessments, Super and his colleagues use the Strong Interest Inventory (SII) to measure Holland's personality and environment theory and the Values Scale (VS) which measures intrinsic and extrinsic values such as achievement, economic rewards, and prestige.

Because of the different views of career theorists, researchers have studied values and interests to see if they are indeed similar constructs. Breme and Cockriel (1975) stated that Holland's definition of interests was similar to Super's definition of values because both definitions discussed an attribute toward which a person strives. For Holland, interests are expressions of one's personality and direct people toward an occupation. For Super, values are desirable attributes which people seek in activities and vocations. Thus, Breme and Cockriel (1975) used the Work Values Inventory devised by Super and the Vocational Preference Inventory devised by Holland to assess the similarities and differences between the two constructs of interests and values. These researchers found the assessments to be measures of two distinctive domains. This finding means that values and interests give us different information to be used in career decision making.

In the field of engineering, researchers have investigated different relationships with regard to values. An example of some studies include: the relationship of values and occupational role perceptions of freshmen and senior engineering students (Olive, 1969), the differences between work values of liberal arts and engineering students (Neumann & Neumann, 1983), comparing values of engineers with managers, production, and clerical workers (Shapira & Griffith, 1990), and comparing career, home, and leisure values of male and female engineering and science students (Cooper & Robinson, 1987). While these studies have compared engineers to other occupations or majors, it would be helpful to investigate whether or not there are differences among engineering fields using both interests and values inventories. This information could assist colleges of engineering by helping students find their occupational fit and thus continue to major in engineering as well as stay in the field after college graduation. This support is important because the number of engineering graduates has dropped over the years while the demand for engineering professionals has increased.

## Need for the Study

While reviewing previous research on the interests and values of engineering students, two themes emerged: (a) there is disagreement on whether interests and values are two separate constructs and (b) although there are studies that compare the interests and values of engineering students and professional engineers to other college majors and occupations, no studies have been found which focus on the relationship of interests and values in the fields of engineering. These two themes, coupled with the increased demand for engineering professionals, establish the need for conducting a study that could result in information to assist career counselors and academic advisors when working with engineering students in their career decision making process.

## Research Questions

The present study investigated the relationship between the Self-Directed Search, an interest inventory based on a model of six personality types, and the Values Scale, a values inventory, for students with senior standing in different fields of engineering. The research questions that were examined include:

1. What is the relationship between values of undergraduate engineering students as measured by the Values Scale and their personality types as measured by the Self-Directed Search?
2. Is there a significant difference between (a) male and female engineering students, (b) undergraduate engineering students who have cooperative education (co-op) experiences and those who do not, (c) undergraduate engineering students who have engineering work experience and those who do not, and (d) engineering students who participate in undergraduate research and those who do not in terms of Personality types? Values factors?
3. Is there a significant difference between majors in undergraduate engineering fields offered at The University of Tennessee with regards to Personality types? Values factors?

## Definitions of Terms

There are several terms that will be used throughout this study.

Self-Directed Search (SDS): a career counseling assessment designed by John Holland to measure one's self reported interests.

Personality types: each of the six interest areas represented on the Self-Directed Search: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional.

Personality profiles: the three letter Holland codes obtained on the Self-Directed Search that correspond to three of the six personality types.

Values Scale: a career counseling tool created by Dorothy Nevill and Donald Super to measure intrinsic and extrinsic values.

Values: correspond to the 21 values that are measured on the Values Scale: Ability Utilization, Achievement, Advancement, Aesthetics, Altruism, Authority, Autonomy, Creativity, Economic Rewards, Life Style, Personal Development, Physical Activity, Prestige, Risk, Social Interaction, Social Relations, Variety, Working Conditions, Cultural Identity, Physical Prowess, and Economic Security.

Values factors: the five factors represented on the Values Scale: Inner-Orientation, Group Orientation, Material, Physical Prowess, and Physical Activity.

Senior standing: undergraduate students who have 90 or more of the 124 credit hours needed for graduation.

Engineering fields: individual areas of study under the engineering major at The University of Tennessee which includes: aerospace, biomedical, chemical, civil, computer, electrical, engineering physics, engineering science, industrial, materials science and engineering, mechanical, and nuclear.

Cooperative education (co-op): commitments that students make to companies to work full time two or more consecutive or non-consecutive semesters. At The University of Tennessee this is an optional program for undergraduate students, however 43% of engineering students chose to participate.

Engineering work experience: engineering experience that was not a cooperative education program such as summer or holiday work.

Undergraduate research: research that a student has done outside of class either as the principal investigator or as an assistant to a faculty member.

## Limitations of the Study

It is important to make note of the limitations of this study. This study investigated differences that exist between engineering students with regard to interests and values; however, it did not be focused on why the differences exist or what the possible causes of the differences might be. While these areas of study are important and encouraged, the nature of the present study was to simply find if differences do exist. It is also important to remember that this study was being conducted with college students and may not be generalizable to engineers in the world of work.

The differences in undergraduate research and co-op experiences at The University of Tennessee may not be the same as other universities. For example, there are engineering colleges at universities such as Northeastern University that require all students to participate in co-op programs.

Because this study explored the interests and values of established senior students in The University of Tennessee College of Engineering, it is important to realize the possibility that students who are different from this sample left engineering because their interests and values differed from those who remained in school.

Finally, it is important to acknowledge the influence of skills and abilities in career development and decision making. Although the Self-Directed Search includes self-estimates of general skills and abilities, there was no testing of specific engineering skills and abilities in the present study. It is assumed that those students without the skills and abilities to be an engineer would have left or been dismissed from the program at this point in their academic career.

The theoretical background, need, research questions to be addressed, definition of terms, and limitations of this study have been presented in Chapter I. Chapter II contains a review of relevant research that will further establish the context of this study.

# CHAPTER II

## LITERATURE REVIEW

This chapter will review relevant research about interests, values, and engineering that will aid in the understanding of the need for this study. The research on interests will include studies about the early investigations of interests, information about John Holland's theory of interests and career decision making, and limitations found in the literature regarding Holland's theory and model. The literature on values describes the conflict in beliefs between John Holland and Donald Super regarding the importance of assessing values in career decision making and discusses studies about engineers' values. The section on engineering research focuses on the impacts of gender, cooperative education programs, and undergraduate research on the experience of engineering students.

### Interests

The complex phenomena of linking vocational interests and occupational choice has been studied for many decades (Berdie, 1943). One of the first assessments of vocational interests was the Strong Vocational Interest Blank (SVIB). The SVIB was first published in 1927 by E.K. Strong, Jr. to represent the degree of similarity between one's interests and those interests of individuals in various occupations (Campbell & Borgen, 1999; Osborne, Brown, Niles, & Miner, 1997). Development and continued evaluation of this assessment allowed for easier measurement of interests and encouraged research on the topic of vocational interests and occupational choices. While the early version of the SVIB did not have a theoretical structure, it still offered an assessment of interests which researchers could use to investigate vocational behavior (Campbell & Borgen, 1999).

Early studies of interests focused on what factors within one's background, such as family relationships, socioeconomic status, personality, and skill and abilities, were related to vocational interests and ultimately vocational choices (Berdie, 1943). This review of interests will first explore the early investigations that were undertaken to gather a better understanding of the relationship between vocational interests and personality. The second part will focus on John Holland's contributions to this important area of study as well as empirical investigations into his theory of vocational interests and personality. Finally, studies that describe limitations of Holland's theory will be discussed.

Early Investigations

The idea that personality and interests are related is not a new concept. This relationship was assessed in a number of early studies. Dunnette, Kirchner, and DeGidio (1958) were interested in the relationship between the Edwards Personal Preference Schedule (EEPS), the California Psychological Inventory (CPI), and the SVIB. They gave these assessments to 102 employees of the Minnesota Mining and Manufacturing Company. While the focus of this study was on the utility of the EPPS and the CPI as aids in career counseling, the authors found that the two personality assessments were moderately correlated with the SVIB. Siess and Jackson (1970) wanted to assess the common domains of vocational interest measurements within the framework of personality theory measurements. They asked 212 males enrolled in an introduction to psychology class at the University of Western Ontario to complete the SVIB and the Personality Research Form (PRF) and found that the SVIB scales provide the counselor with a foundation to make statements about needs patterns which specific occupations can satisfy. It was also determined that the PRF could be used in occupational settings.

Another study used the Omnibus Personality Inventory and the Interest Assessment Scales to measure personality and interests, respectively (Stewart, 1971). The author of this study was interested in how personality and interests predict curriculum choices of 682 females and 1776 males enrolled in junior colleges throughout California. It was found that interests, as measured by the Interest Assessment Scales, were better at predicting curriculum choices. However, the two instruments were found to be so closely related and tapping essentially similar factors that the author felt interests could also be interpreted as personalogical constructs. At the end of the article the author stated that although the assessments were related, they served two different functions and he would not recommend using the two instruments interchangeably.

Johnson, Flammer, and Nelson (1975) were interested in exploring the construct validity of the SVIB Occupational scales by examining their relationship to personality factors. These authors used the California Psychological Inventory as an assessment of personality characteristics for 359 males at the University of Massachusetts, Fordham University, and the University of Manitoba. This inventory's factors were found to account for a statistically significant portion of the variance for the Occupational scales, yet the authors noted that the SVIB Occupational interest scores should not be used as indicators of psychological adjustment. Finally, Costa, Fozard, & McCrae (1977) factor analyzed the occupational and non-occupational scales of the SVIB into five factors based on a sample of 1068 male volunteers in a normative aging study. These factors were then correlated with Cattell's Sixteen Personality Factor (16PF) Questionnaire. The results indicated a relationship between the five factors of the occupational scales and the personality factors of the 16PF.

Each of the studies discussed above have contributed to a better understanding of the relationship between interests, as measured by either the SVIB or the Interest Assessment Scales, and personality, as measured by a variety of instruments. While no measure of personality offered an exact theory for understanding interests as measured by the SVIB, the significant relationship between interests and personality offered initial support for Holland's theory of vocational interests.

John Holland

John Holland first published his theory of vocational interests in the *Journal of Counseling Psychology* in 1959 and continued to publish studies on this topic throughout the 1960s (Gottfredson, 1999). In the 1970s, he proposed a revised version of his theory which stated that vocational choices are directly linked to one's personality and that vocational behavior is determined by the interaction of one's personality and the work environment (Holland, 1997). In order to further understand vocational behavior, Holland felt that psychologists should study six personality types as identified by Guilford's factor analysis of human interests, which Holland named: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional (Campbell & Holland, 1972; Hogan & Blake, 1999). Holland (1997) defines each of these personality types by their preferences and potential competencies.

The Realistic type prefers systematic or ordered manipulation of tools, animals, objects, and machines which leads to competencies in technical, mechanical, agricultural, and electrical fields. The Investigative type prefers systematic observational, and creative investigation of cultural, biological, and physical fields of study and leads to competencies in science and mathematics. The Artistic type has competencies in areas such as language, sculpting, music, drama, or writing because of preferences for activities that call for manipulation of verbal, physical, or human materials to create forms or products of art. The Social type prefers dealing with others in ways such as informing, training, curing, or enlightening so that they develop competencies in human relations. The Enterprising type prefers working with others for economic gain and organizational goals that leads to competencies in leadership and persuasion. Finally, the Conventional type prefers to work with data in a systematic, explicit, and ordered way which tends to lead to competencies in clerical, computational, and business fields. These six personality types were called the RIASEC model.

Holland believed that these personality types could be arranged in a hexagonal model where adjacent types are most similar and types opposite of one another are least similar (Tokar & Swanson, 1995). Holland felt that this hexagon would bring structure, simplification, and organization to the measurement of interests and evidence has supported this structure (Campbell & Borgen, 1999).

The primary principles of Holland's theory are: (a) vocational choice is an expression of personality, (b) interest inventories are personality inventories, (c) similar histories of personal development and similar personalities are shared among members of an occupation, (d) people with similar personalities will respond to situations in similar ways, thus creating a characteristic interpersonal environment and (e) satisfaction, stability, and achievement with one's occupation are dependent on the congruence between personality and the work environment (Holland, 1997). These principles express the foundation of Holland's theory and because the theory is empirically testable, researchers as well as practitioners can and have benefited from its study (Rayman & Atanasoff, 1999).

In order to measure his theory of vocational interests and personality, Holland devised two instruments. First, the Vocational Preference Inventory (VPI) indicates which vocations one likes or dislikes from a list of occupational titles that load on Holland's six personality types (Rayman & Atanasoff, 1999). The other instrument, the Self-Directed Search (SDS), provides the client with insight into career development and choice (Holland, 1997; Rayman & Atanasoff, 1999). This assessment has many advantages, among them is the fact that it provides an effective vocational counseling experience for those who do not actually meet with a career counselor because it is self-scored and self-interpreted (Gottfredson, 1999). The SDS is often seen as the epitome of Holland's theory with regard to career assessment and the instrument has been revised over the years to improve upon item content (Holland, Fritzsche, & Powell, 1994; Reardon & Lenz, 1999).

While Holland was creating a theoretical framework and assessments in which to understand vocational choices, E.K. Strong and his colleagues had been devising an empirically sound measure of occupational scales, the SVIB. After Strong's death in 1963, Campbell continued work on revising the SVIB (Campbell & Borgen, 1999). In 1972, Campbell and Holland published an article about the merging of the SVIB and Holland's theory of six personality types in order to make a more robust measurement of vocational behavior and choices. This monumental merger has proven to be pivotal in the understanding of vocational interests and personality. In 1974 the Strong-Campbell

Interest Inventory was published which was later changed to the Strong Interest Inventory (Campbell & Borgen, 1999).

With the advent of an additional interest inventory based on Holland's theory, many researchers were eager to continue the investigation of the relationship between vocational interests and personality. Wakefield and Cunningham (1975) wanted to explore dimensions of personality measured by the VPI, which is based on vocational theory, and the EPPS, which is based on a needs theory. While the authors found from a sample of 372 juniors (70% female) enrolled in undergraduate teacher education courses that the measures were related, they were not duplicative measures. Ward, Cunningham, and Wakefield (1976) investigated the relationship between the VPI and the 16PF in order to find support for the use of the 16PF as a vocational assessment and the VPI as a personality assessment. These researchers sampled 425 undergraduate students (70% female) at the University of Houston and found that the 16PF did not give a complete picture of Holland's theory of vocational interests, however support was found for the personality interpretations of the VPI and Holland's personality theory of vocations. Additional support can be found in another study that explored Holland types and the 16PF and found associations consistent with Holland's theory (Peraino & Willerman, 1983).

More recent studies of vocational interests and personality have focused on the popular Big Five theory of personality. Gottfredson, Jones, and Holland (1993) found small to moderate correlations between the six vocational personality types of Holland's theory measured by the VPI and the five factors of personality measured by the Neuroticism-Extraversion-Openness Personality Inventory (NEO-PI) when they sampled

479 males and 246 females who were in basic training at US Navy training centers. These authors suggest the usefulness of a supplemental interest assessment which measures Neuroticism, Likability, and Control in addition to the VPI in counseling and organizational applications. An extension of this study was investigated by Tokar and Swanson (1995) when they sampled 490 employed adults in the Midwest. Using the SDS and the NEO-FFI, these researchers found significant similarities between the two models of personality even though the theories were developed independently. However, the five-factor model did not account for Holland's entire RIASEC model. It is suggested that the two assessments could be used in conjunction with one another in order for one to benefit from all the data.

Limitations of Holland's Theory

While exploration of Holland's model of vocational decision making has given support to this theory of personality as measured by interest inventories, there have been a number of critiques regarding the overall relationship of interests and personality as well as critiques of specific aspects of the theory. Hogan and Blake (1999) discuss the fact that personality psychologists and vocational psychologists have largely ignored one another. They believe that this has been a great disservice to both areas of study. These authors propose that the relationship between vocational interest measurements and personality assessments is that vocational interests describe the fit of one's interests to the interests of potential co-workers and personality explains a person's potential to get along and get ahead in a career that they like. They continue by saying that interest inventories directly measure one's identity while a personality assessment indirectly measures one's reputation and characteristic behavior. It is stated that both measurements can forecast occupational success and are thus related, but not identical.

Other critiques of Holland's theory are concerned with the labeling of the personality types as well as the hexagonal model in which they are presented. When Costa, Fozard, and McCrae (1977) factor analyzed the SVIB they found only five factors which could be described as dichotomous such as person versus task, tough versus tender-minded, and business versus healing. Dawis (1992) also noted that the hexagonal shape of personality types was different for different samples. She stated that there has been robust support for the RIASEC model, however support for the equilateral hexagon is lacking. She contends that support for the hexagonal model has been derived from instruments constructed to yield the six personality types and thus there is circularity in the argument. Prediger and Vansickle (1992) report that person-environment fit of the RIASEC model can be more precisely discussed from a two-dimensional map with People/Things on one axis and Data/Ideas on the other (Dawis, 1992; Tokar & Swanson, 1995). This visual map would allow clients to observe their location on the axes and determine which occupations were closest to his or her interests, thus extending Holland's hexagon beyond the RIASEC model. Lastly, Schwartz (1992) noted limitations in Holland's concept of congruence which is defined as interpersonal similarity in a particular environment. It is argued that congruence may only be evidenced in studies of vocations where the vocational image is clear and closely related to the vocational reality. Schwartz believes that the development of occupation-specific personality and environment fit tests would be more valid than the inventories currently being used.

## Values

The sparse literature on values in career development appears to be in conflict. John Holland believes that knowledge of interests is more informative than knowledge of values (Holland, 1997). Holland (1997) does not believe that assessing values gives substantial information above what is gathered from an interest inventory. However, Donald Super (1992) believes that knowledge of one's values is of utmost importance when making career decisions. He recognizes the relationship between interests and values, yet feels the need to assess both constructs when working with clients who are making career decisions. This section will further illustrate Holland's view of values, explore the importance Super puts on values, and describe studies of values and engineering.

### Holland's View of Values

Holland (1997) stated that the association of values to personality types has been consistent with his description of the different types. He reported that Investigative types value scientific achievements, Artistic types value artistic accomplishment, Social types value altruism and religion, and Enterprising and Conventional value political and economic advancement. He also reported that studies have found that when values and interests inventories are given to discriminate between groups, values provide only a little information beyond what is provided by knowledge of interests alone. He ultimately stated that "values inventories typically do not discriminate efficiently among occupational fields. (Holland, 1997 p.145)" However, the present study is interested in the benefits of the knowledge of values within a specific occupational field when interests appear to be similar.

Super's View of Values

Another career development theorist, Donald Super (1992), stated that a multifaceted view of the many factors that affect career development and decision making should be considered. People differ in their abilities, interests, traits, and values; thus each person's unique characteristics should be explored. While values and interests are related, he thought that individuals' values are the basis on which goals are established and provide guidance in making meaningful and consistent decisions. Values are an important element of the career decision making process and can be defined as the objectives which are sought in behavior (Osborne et al., 1997). There are both work and lifestyle values. For instance, work values would include whether or not one would mind wearing a uniform to work, which shift he or she worked, salary, or if they worked directly with people or not. Lifestyle values would include where he or she lived, whether or not one lived with another person, or the importance of spiritual or religious concerns. Super also classified values as intrinsic, meaning those inherent in an activity or extrinsic, meaning those which are outcomes to participating in an activity (Neumann & Neumann, 1983). Osborne and colleagues (1997) stated that interests, on the other hand, have been defined as the activities in which values are sought. They stated that values and feelings are the affective components to decision making (Osborne et al., 1997). By raising awareness of an individual's values through assessment, he or she can use them in a more conscious manner. For example, happiness can be derived by participating in meaningful life activities. Thus by identifying values, or what is meaningful and important, a good decision can be made so that happiness can be ensured.

Values and Engineering

A few studies were found that were concerned with the values of engineering students or engineers. Olive (1969) was interested in determining if engineering students showed an increasing degree of congruence between their values and their perceptions of their jobs as they got closer to graduation. He had 321 freshmen males enrolled in engineering at the University of Nebraska as well as the graduating engineering class of 1965 complete the Poe Inventory of Values and an "orientations toward work" assessment developed to measure student's perceptions of their chosen occupation. Results indicated that senior students perceive the occupation of engineering to be more in harmony with their values than freshmen students. This finding supports the present study's use of senior level students to explore the values of engineering majors. In 1983, Neumann and Neumann had 120 students from either the College of Liberal Arts or the School of Engineering in a major university in Israel complete the Work Values Inventory. They found that work values could predict the degree of interest and choice of academic program. This finding is significant given that it contradicts research that Holland noted.

Another study compared the career, home, and leisure values of 100 males and 100 females who were science or engineering majors at a midwestern university (Cooper & Robinson, 1987). Students were asked to complete the Work Salience Inventory in order to explore if female engineering and science majors would score higher than men on career-related values. This hypothesis was supported and it was found that males and females did differ on the importance of home and family. Thus, male and female engineering students' values may differ and it is important to assess their differences. Finally, Shapira and Griffith (1990) were interested in the work values of engineers, managers, production, and clerical employees working in a production plant. They had 432 employees (74 females, 358 males) in two manufacturing plants complete the Survey of Work Values. Engineers and managers were found to differ on activity preference, pride in work, and attitudes toward earnings. No other significant differences were found. This finding may have implications for engineering teams within one company. It may be important for engineers and managers to explore and understand their values even in the working world, when they work together.

## Engineering

The importance of exploring engineering as well as specific fields of engineering beyond Holland's model is to aid in retention of students in colleges of engineering. The knowledge gathered by this and other studies can be used when working with freshmen and sophomores who have been successful in engineering and are trying to decide which field to study. Helping engineering students learn about which fields of engineering match their interests and values can lead students to more educated career decisions. The more that is learned about how to differentiate engineering fields the more help advisors and counselors can be to these students.

Retention of engineering students has been a concern for both educational institutions and industry for over 30 years. Studies on retention at The University of Tennessee have focused on finding a series of complex variables that predict what types of students will persist or finish their undergraduate degree in the College of Engineering. The overall retention rate of freshmen in Colleges of Engineering across the country has typically remained low, at only 40% to 50% (Dececchi, Timperon, & Dececchi, 1996). This rate means that 50% to 60% of the students who enter engineering are leaving. At the

University of Tennessee the retention rate of those who enter and receive a degree in the College of Engineering is 43% (Fred Gilliam, personal communication, September 22, 1999). Retention has been a concern in part because engineers provide a high percentage of the technical workforce and the demand for engineers will continue to increase (Hermond, 1995). The topic of retention rates has been a focus of university professors and administrators for several reasons. Retention rates have been used to compare institutions and to judge program effectiveness, thus making this topic key in the competition to recruit and keep the best students. Some administrators see individuals transferring to other academic programs as a negative reflection on the engineering program's goal to retain its members (Dececchi, Timperson, & Dececchi, 1996). It has also been found that it is more expensive to recruit new students than it is to keep current ones (Moller-Wong & Eide, 1997).

The literature about engineering programs makes note of three different experiences that engineering students can have which may be related to retention and career decision making. The first experience is linked to the demographic make up of students. For the purposes of this study the focus will be on gender. There have been a number of studies that describe women's experiences in engineering as different from males (Takahira, Goodings, & Byrnes, 1998; Tonso, 1996). The second experience is whether a student participates in a cooperative education (co-op) program or not. This experience will vary from institution to institution. At The University of Tennessee participation in a co-op program is voluntary. However, at other universities, for example, Northeastern University, participation in a co-op program is mandatory for all students. Students can also participate in engineering work that is not a co-op program. Often students will get summer or holiday work that allows them to perform engineering tasks. The third experience is involvement in undergraduate research. Participation in research as an undergraduate appears to be optional at most universities. However, those students who chose to have this experience may have different interests and/or values from those students who decide not to participate in research.

<u>Gender</u>

Various demographic variables have been explored as to their relationship to retention. Special attention has focused on the persistence of women in the College of Engineering because their retention rates have been significantly lower than those of males. With only 19% of engineering students nationwide being female (Taylor, 1997), the loss of even a small percentage of these students can change the diversity of an engineering program. Across 17 institutions (4993 males, 1123 females), it was reported that men persisted at a rate 15% higher than the rate for women in engineering (Takahira, Goodings, & Byrnes, 1998). Retaining women is especially important when the male-to-female ratio in engineering undergraduate programs from the same study was nearly 5 to 1 (Takahira, Goodings, & Brynes, 1998). In 1998, according to the National Science Foundation, 11,339 women graduated with Bachelor's degrees in engineering while 49,575 men obtained Bachelor's degrees in engineering (NSF, 2001). Researchers studied female cadets at the Royal Military College of Canada and found that women have the most problems in their first year of the engineering program (Dececchi, Timperon, Dececchi, 1996), and others have found that women tend to leave engineering after fewer semesters than men (Whigham, 1985). The first few semesters is the time when, if women feel they cannot succeed due to low grades, they feel they are not being taken seriously in the classroom, or they are not comfortable with fellow students, they will transfer to another academic program (Gardner & Broadus, 1990). Karen Tonso's (1996) qualitative research of a sophomore engineering design class highlighted many cultural norms in engineering which work to the disadvantage of women students and faculty. This focus is important because 75% of the new entrants into the workforce will be women during this new century, and with the supply of engineers dwindling, the profession cannot afford the high attrition rate of qualified candidates (Hermond, 1995). In one study of 1779 freshmen (1514 male, 236 female) enrolled in engineering at the University of Texas-Austin, the attrition rates for women were 41.1% (Durio, 1980). These previous studies show the importance of including gender when exploring retention and career development in engineering.

Cooperative Education (Co-op) Programs

Co-op programs began in engineering at the University of Cincinnati in 1906 and have proven to be a great tool for students (Whitaker, 1998). The major purpose of a cooperative education program is for students to develop occupational competence through application of theoretical knowledge and principles already gained through course work to challenging problems encountered in industry (Varma, 1998). Participating in a co-op program can help to increase confidence in students' strengths and make them aware of what areas of study still need attention and development (Lozano-Nieto, 1998). It is hoped that this experience will give students a clearer picture and deeper understanding of what the engineering profession entails on the job as well as the perspectives and behaviors that take place in industry (Hackett, Croissant, & Schneider, 1992). It is the mission of industry and education to create competitive job-ready graduates through their experiences in co-op programs (Lozano-Nieto, 1998; Varma, 1998). At The University of Tennessee, undergraduate engineering students can choose whether or not they would like to participate in a co-op program. Some students choose not to co-op because they fear that the experience will delay their graduation. However, at The University of Tennessee, statistics show that those who do not participate in co-op programs graduate in 4.9 years and those who do participate in a co-op program graduate in 5.1 years. Thus, their fear of delayed graduation is simply a myth.

A number of other benefits of participation in co-op programs have been documented. In one study, students who participated in a Biomedical program all evaluated their co-op experience as positive (Lozano-Nieto, 1998). These students stated that their participation gave them a clear view of their future workplace as well as needed "real" experience before graduation. Another documented benefit is that employers tend to offer more job opportunities to students who have been involved in co-op programs versus those students who have not participated (Lozano-Nieto, 1998). It appears that co-op experiences influence students' skills and career decisions due to the nature of having been immersed in the world of work (Hackett et al., 1992). According to annual surveys of over 200 students who participated in co-op programs at Murray State University, over 70% of the students felt that their on-the-job experience lead to an employment offer (Whitaker, 1998). In the same study at Murray State University, Whitaker (1998) found that students who were in a co-op program had a 9% higher starting annual salary than those who did not have an on-the-job experience.

The "success" of co-op programs has been measured as various outcomes of the experience. One indicator of success in a co-op program has been measured by supervisors' ratings of students' on-the-job performance (Hackett, Martin, & Rosselli, 1998). In one study, Hackett et al. (1998) surveyed 271 engineering students from nine US engineering schools and found that high performance ratings were most highly related to high academic achievement as measured by grade point average (GPA). This finding could have implications on who should participate in co-op programs. A second indicator of students' success in a co-op program is to measure improvement in specific cognitive skill areas such as communication, problem-solving, teamwork, and goal setting (Bayless, 1999; Hackett et al., 1992). Bayless (1999) surveyed students who participated in co-op programs in 1996, 1997, and 1998 and found that most participants indicated some improvement in all cognitive areas, however the greatest improvements were reported in personal communication skills and communication skills within groups. A third indicator of students' success in co-op programs has been the participants' reported satisfaction with their experiences (Riess, 1999). A study by Riess (1999) sampled 1996 graduates who participated in the co-op program at Virginia Tech and found satisfaction with the co-op program to be defined by the opportunity to experience corporate culture, make contacts, establish a better sense of self-worth, link classroom knowledge to "real world" experience, and verify one's choice of major. Because they had these opportunities, the students viewed their co-op participation as having been successful.

While there are several benefits to participating in a co-op program there are still a large number of students at The University of Tennessee who chose not to participate.

There are students who choose not to co-op but see the benefit of participating in some type of engineering work experience while they are in college even if it is not the formal College of Engineering co-op. Many of the benefits mentioned above with regards to having a co-op experience such as experiencing corporate culture, making contacts, establishing a better sense of self-worth, linking classroom knowledge to "real world" experience, and verifying one's choice of major can also be gained from participating in some type of engineering work experience. The work experience might be employment over the summers, during the holidays, or even part-time work during the school year. Because students have the option of having this different type of engineering work experience, participants in the present study were asked about their participation in engineering tasks outside of a formal co-op experience.

Undergraduate Research

Participation in undergraduate research projects is also believed to provide many benefits to students. Authors theorize that participants develop expertise, gain an understanding of the research process and its practice as well as acquire a number of skills such as team building, communication, problem-solving, and higher-level thinking (Gates, Teller, Bernat, Delgado, & Della-Piana, 1999). In 1990, a survey of 436 engineering students enrolled at Hilltop Tech asked students to report their skills and abilities acquired during college (Hackett, Croissant, & Schneider, 1992). The survey indicated that research allows for hands-on experience in the production on new knowledge, gives a closer appreciation of academic work, and is a chance to know and become better known by faculty (Hackett et al., 1992). Gates and her colleagues (1999) also think that this experience promotes interaction among students and between students and faculty. This interaction is what helps to increase student retention, especially if the student starts research participation early on. While there have not been many studies on the outcomes of participation in research as an undergraduate, there are authors who advocate that all students should have research experience (Gates et al., 1999; Hackett et al., 1992). Typically, only a small number of students participate in research and usually it is those students who are seen as being the most competent. Also, many students do not participate because of factors such as time needed to work due to financial problems or the fact that some students fear that they are not be able to contribute. However, there are research models such as the Systems and Software Engineering Affinity Research Group/Laboratory (SSEAL) that hope to include students who have a wide variety of experiences, talents, skills, and interests in a research experience (Gates et al., 1999). Students are encouraged to participate in research as an undergraduate. It is hoped that they will profit from the number of benefits already discussed.

There have been various studies that have explored the demographics of students who were retained in engineering (Takahira, Goodings, & Brynes, 1998; Besterfield-Sacre, Atman, & Shuman, 1997; Levin & Wyckoff, 1988, 1990, 1995), the outcomes and successfulness of co-op programs (Hackett, Martin, & Rosselli, 1998; Lozano-Nieto, 1998; Varma, 1998; Whitaker, 1998), and the benefits of participation in undergraduate research (Gates et al., 1999; Hackett et al., 1992). However, there is a need to study the differences and similarities of interests and values between males and females, students who co-op and those who do not, and students who participate in research and those who do not within a variety of engineering fields. The information about values of engineering students, which may be related to retention, career development, and career decision making, could give advisors and counselors a step beyond Holland's model.

In order to gather a deeper understanding for the need of the present study, the relevant research regarding interests, values, and engineering has been discussed in Chapter II. The participants, procedure, research and statistical design, and materials will be presented in Chapter III.

# CHAPTER III

# METHOD

The focus of Chapter III is to fully describe how the present study was conducted. Documentation, which supported the data collection phase of this study, is included in appropriate appendices.

## Participants

One hundred and sixty-five undergraduate engineering students, 125 males and 39 females, who had senior standing at The University of Tennessee completed an assessment packet. Senior standing means that a student has 90 or more of the 124 credit hours needed for graduation. The average reported age of the sample was 24.28 and ranged from 20 to 49 with 37% of the students being 22 years old. The average reported GPA for the sample was 3.27 and ranged from 2.15 to 4.0. The majority of the sample reported being Caucasian (n=135); however, other ethnicities were reported: Asian/Pacific Islander (n=14), Black/African American (n=9), American Indian/Alaskan Native (n=2), Hispanic (n=1), and Other (n=4). The martial status of the sample was: single (n=134), married (n=30), and remarried (n=1).

Participants were mainly from Tennessee (n=122). However, there were several from outside the state of Tennessee (n=35) and still others were from outside the United States (n=8). The sample for the study includes students from eleven engineering fields: Aerospace (n=5), Biomedical (n=11), Chemical (n=27), Civil (n=24), Computer (n=7), Electrical (n=26), Engineering Physics (n=2), Engineering Science (n=1), Industrial (n=29), Material Science and Engineering (n=5), and Mechanical (n=27). Finally, several students reported having received scholarships during their undergraduate career.

When participants were asked about scholarships they had received and the amount received during their entire enrollment at The University of Tennessee, seventy-five students reported having scholarships that ranged from $500 to $53,550. The average scholarship amount received was $10,952.

At The University of Tennessee students have a choice of whether or not they would like to participate in a Cooperative Education (Co-op) program. In this sample, 62 students, 42 males and 20 females, participated in a co-op program. The average age of those participating was 23 years old. Students also participated in summer and holiday engineering work not classified as a co-op experience. Eighty-seven students, 69 males and 18 females, indicated that they had engineering work experience. Their average age was 24 years old. There were several students who participated in both a co-op program and an engineering work experience. The average age was 24 years old for those 25 students, 19 males and 6 females, who reported both experiences. The students also have a choice of whether or not they participate in research. Thirty students, 23 males and 7 females, indicated that they participated in research as an undergraduate. Six students reported doing their own original research and 24 students indicated that they worked on research started by a faculty member.

There were several personality profiles or three-letter Holland codes represented in this sample of 165 students. Thirty-two different personality profiles were indicated. The only personality type not found in the first position of the profile was Social. The four primary profiles were: RIE (n=27), IRA (n=16), IRC (n=14), and REI (n=14).

## Procedure

Contact was made with each of the professors of senior design, capstone, and seminar classes in eleven of the twelve engineering departments (aerospace, biomedical, chemical, civil, computer, electrical, engineering physics, engineering science, industrial, materials science and engineering, and mechanical) to request a date to talk with the students in these classes and distribute assessment packets. There were no nuclear engineering students slated to graduate in May 2001; therefore, no nuclear engineering student completed an assessment packet. Biomedical engineering is considered to be a concentration under the Engineering Science major, thus students were asked to identify their concentrations.

The letter appearing in Appendix A was sent to each of the professors to give further information about the purpose and intent of the study. Assessment packets were collected in two ways. Several professors allowed the experimenter to use class time to administer the packet and collect them immediately. Other professors allowed the use of class time for distribution of the assessment packet only and completed packets were given to the professor of the class at a later date. The experimenter then gathered the completed packets and kept them in a locked filing cabinet. No follow-up meetings with participants were held, however each participant received contact information should he or she have questions about his or her own career planning or results from the assessment packet.

## Research and Statistical Design

A post-test only cohort design was used in the present study. Cohort designs are stronger than nonequivalent group designs because cohorts' environments are more likely to be the same (Heppner, Kivlighan, & Wampold, 1999). In this study, all engineering students are from similar cohorts, meaning that they entered the College of Engineering at about the same time, probably Fall of 1995, 1996, or 1997. All students shared the same freshman year experiences in engineering and from then on students in the same field shared the same classes and projects. The only exception to this was ten students who participated in the 1997 pilot study of the ENGAGE program. The ENGAGE program is for entering freshman and involves teaming students on project-oriented, hands-on activities. The post-test only design of this study means that all cohorts had a one time administration of the same assessment packet during the Spring 2001 academic semester.

Statistical tests varied by the research question being asked. The Pearson's Product Moment Correlation was used to assess the relationship between values and personality types. A series of MANOVAs and ANOVAs were used to ascertain whether there were significant differences on values and personality types (a) between males and females, (b) those who had co-op experiences and those who did not, (c) those who had engineering work experience and those who did not, and (d) those who had participated in undergraduate research and those who had not. Several types of tests (a series of MANOVAs and ANOVAs, and post-hoc Tukey tests) were required to answer whether personality types and values differed from each other by specific field of engineering.

## Materials

Each participant received an assessment packet in a 9X12 envelope which included two Student Information/Informed Consent forms, an Information Sheet, the Self-Directed Search, and the Values Scale. Within the envelope, the assessments were stapled together and the order of the Self-Directed Search and the Values Scale were alternated to ensure that an order effect did not occur.

Student Information/Informed Consent

Two copies of a letter to each participant were included in the assessment packet. The letter described the study and requested their participation in the study. It gave the participants contact information and requested that they keep one copy of the letter for their records. A copy of the letter can be found in Appendix B.

Information Sheet

Demographic data related to the research questions was gathered via an Information Sheet. A copy of the Information Sheet is in Appendix C.

The Self-Directed Search

The Self-Directed Search (SDS) is a career counseling tool created by John Holland which can be used in the absence of a career counselor (Holland, Fritzsche, & Powell, 1994). It can be self-administered, self-scored, and self-interpreted. This assessment was explicitly derived from John Holland's theory of personality types and environmental model of career decision making. That theory assumes that individuals seek out environments where they will have the greatest opportunity to express their personality (Daniels, 1994). Thus, it purports to measure Holland's theory and RIASEC model he created. Publisher information for this assessment can be found in Appendix C.

The 1994 edition of the "R form" of the SDS was developed for use with high school and college students as well as adults and was used in this study. This form has five different sections. The first section is called "Occupational Daydreams" and asks the participant about his/her occupational aspirations. The second section is an "Activities

Scale" which measures personal involvement and potential. The "Competencies Scale" is used as an estimate of the participant's aptitudes and proficiencies. The fourth part is the "Occupations Scale" which asks participants to endorse occupations that correspond to each of the RIASEC interest areas. Lastly, the "Self-Estimates" asks for self-ratings on each of the types. Only the Activities, Competencies, Occupations, and Self-Estimates are used to determine the participants three letter Holland summary code or personality profile. For example, a SEC summary code means that the participant's primary interests fall under Social, secondary interests fall under Enterprising, and tertiary interests fall under Conventional.

According to the SDS Technical Manual (Holland, Fritzsche, & Powell, 1994), the test-retest reliability ranging from four to twelve weeks of the summary codes ranged from .76 to .82, which shows substantial stability. The internal consistency coefficients for the Activities, Competencies, and Occupations ranged from .72 to .92 while the range was .90 to .94 for the summary code.

The SDS has average to high concurrent validity. Concurrent validity was determined by assessing the "percentage of hits," which is described as the percentage of the sample whose high point code and occupational code or one-letter aspiration agree (Holland, Fritzsche, & Powell, 1994).

Values Scale

The Values Scale was created by Dorothy Nevill and Donald Super in 1989 to measure intrinsic and extrinsic values (Slaney & Suddarth, 1994). Publisher information for this assessment can be found in Appendix C. The predecessor to the Values Scale was the Work Values Inventory created by Super in 1970, but some of the scales on that inventory were not as reliable as he would have desired. The Values Scale was developed as part of the International Work Importance Study that brought together psychologists in Europe, Asia, Africa, Australia, and North America to investigate values and the satisfaction people pursue in work and other life roles (Osborne, et al., 1997; Slaney & Suddarth, 1997). The assessment examines 21 values: Ability Utilization, Achievement, Advancement, Aesthetics, Altruism, Authority, Autonomy, Creativity, Economic Rewards, Life Style, Personal Development, Physical Activity, Prestige, Risk, Social Interaction, Social Relations, Variety, Working Conditions, Cultural Identity, Physical Prowess, and Economic Security. The researchers determined which values to cover by conducting a literature review and then wrote definitions for each value (Osborne, et al., 1997). Each value has five items on the assessment for which there are four possible responses: 1-of little or no importance, 2-of some importance, 3-important, 4-very important (Slaney & Suddarth, 1994). Of these five items, two represent work-related values and two represent general life values. The final item was selected due to its empirical strength.

The values were also factor analyzed which produced five separate factors. These factors can be examined and explored by using the mean of the scores for each of the values that make up each factor. The factors are: Inner-Orientation, Group-Orientation, Material, Physical Prowess, and Physical Activity. Inner-Orientation is composed of the following values: ability utilization, achievement, aesthetics, creativity, personal development, altruism, autonomy, and lifestyle. Group-Orientation is composed of the following values: social interaction, cultural identity, social relations, working conditions, altruism, and variety. Material is composed of the following values: advancement, economic rewards, economic security, prestige, authority, autonomy, and lifestyle. Physical Prowess is composed of the following values: physical prowess, risk, and authority. Finally, Physical Activity is composed of the following values: physical activity and variety. In some cases, values loaded on more than one factor thus there is some relationship among the factors.

The test-retest reliability was conducted only on college students over a two to four week interval and resulted in correlations of .70 for most scales, however five scales fell below .70 (Osborne, et al., 1997; Slaney & Suddarth 1994). Internal consistency was measured by alpha coefficients and were above .70 for high school students, college students, and adults (Osborne, et al., 1997).

Slaney and Suddarth (1994) support the face validity of the item pool that created the Values Scale; however, there have not been any published longitudinal studies on the predictive validity of the scale because it is relatively new. Content validity was established through examination of the methods used to develop the items and the item-scale correlations (Osborne, et al., 1997). After extensive research of the values to be included, item selection was accomplished through factor analysis to assure internal consistency and scale independence. Construct validity was assessed through the examination of normative mean differences for values between females and males. More differences were found between males and females in terms of which values were preferred in high school than in college or adulthood. It was found that as education and age increase there was less propensity for sex-stereotypic values to exist (Osborne, et al., 1997). Other evidence of construct validity comes from a study in Melbourne, Australia that found positive correlations between the Values Scale and the Work Aspect

Preference Scale when given to 400 high school students as well as the Work Quiz when given to 700 high school students (Nevill & Super, 1989). Further evidence of validity was supported when the Values Scale and the Minnesota Importance Questionnaire in addition to the Work Values Inventory were found to measure highly similar constructs (Nevill & Super, 1989).

In order to fully understand the sample and design of the study, Chapter III has described the participants, procedure, research and statistical design, and materials related to the present study. In Chapter IV the research questions as well as the analyses and results of those questions will be given. The definition of terms that are important to the results will also be reviewed.

CHAPTER IV

RESULTS

The results of this study will be presented in Chapter IV. Each research question will be restated and the analysis and findings will be noted. Additional analyses will also be noted.

Research Question 1

What is the relationship between values of undergraduate engineering students as measured by the Values Scale and their personality types as measured by the Self-Directed Search?

The Pearson's correlation matrix seen in Table 1 presents several statistically significant correlations. The Realistic personality type was significantly positively correlated with the following values: Creativity ($p < .001$), Physical Activity ($p = .001$), Risk ($p = .001$), and Physical Prowess ($p < .001$). The Investigative personality type was significantly positively correlated with the following values: Achievement ($p = .018$), Creativity ($p < .001$), Personal Development ($p = .035$), and Risk ($p = .027$). The personality type Artistic was significantly positively correlated with the following values: Achievement ($p = .010$), Aesthetics ($p < .001$), Altruism ($p = .001$), Creativity ($p = .007$), Personal Development ($p = .002$), Prestige ($p = .001$), Social Interaction ($p = .003$), Variety ($p = .006$), Working Conditions ($p = .013$), and significantly negatively correlated with Economic Rewards ($p = .036$). The Social personality type was significantly positively correlated with the following values: Aesthetics ($p < .001$), Altruism ($p < .001$), Personal Development ($p = .001$), Prestige ($p = .011$), Social Interaction ($p < .001$), Social Relations ($p < .001$), Variety ($p = .001$), Cultural Identity

Table 1

Correlations Between Personality Types and Values

| | R | I | A | S | E | C |
|---|---|---|---|---|---|---|
| Ability Utilization | .091 | .089 | .081 | .011 | .013 | .078 |
| Achievement | .154 | .186* | .202* | .059 | .153 | .231** |
| Advancement | .047 | -.052 | -.091 | -.055 | .272** | .173* |
| Aesthetics | .102 | .102 | .284** | .317** | .078 | .106 |
| Altruism | .109 | .164* | .281** | .431** | .037 | .138 |
| Authority | .027 | -.024 | .059 | .120 | .472** | .175* |
| Autonomy | .084 | .075 | -.042 | -.052 | .288** | .009 |
| Creativity | .296** | .377** | .213** | .136 | .069 | -.014 |
| Economic Rewards | -.121 | -.086 | -.166* | -.233** | .148 | .136 |
| Lifestyle | .051 | .122 | .029 | .024 | .139 | .016 |
| Personal Development | .146 | .166* | .240** | .264** | .178* | .107 |
| Physcial Activity | .270** | -.134 | .070 | .108 | .240** | .025 |
| Prestige | .107 | .151 | .254** | .201* | .279** | .138 |
| Risk | .250** | .175* | .100 | .091 | .187* | -.066 |
| Social Interaction | .000 | -.064 | .232** | .383** | .272** | .052 |
| Social Relations | .049 | .053 | .137 | .273** | .195* | .126 |
| Variety | .152 | -.033 | .216** | .249** | .221** | .046 |
| Working Conditions | .031 | .015 | .196* | .041 | -.015 | .257** |
| Cultural Identity | .086 | -.112 | -.010 | .185* | .117 | .168* |
| Physical Prowess | .312** | -.069 | .010 | -.028 | .021 | -.070 |
| Economic Security | .017 | -.093 | -.151 | -.196* | .007 | .161* |

Note: R = Realistic, I = Investigative, A = Artistic, S = Social, E = Enterprising, C = Conventional

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

(p = .019), and significantly negatively correlated with Economic Rewards (p = .003) and Economic Security (p = .013). The Enterprising personality type was significantly positively correlated with the following values: Advancement ($p < .001$), Authority ($p < .001$), Autonomy ($p < .001$), Personal Development (p = .024), Physical Activity (p = .002), Prestige ($p < .001$), Risk (p = .018), Social Interaction ($p < .001$), Social Relations (p = .013), and Variety (p = .005). The personality type Conventional was significantly positively correlated with the following values: Achievement (p = .003), Advancement (p = .028), Authority (p = .026), Working Conditions (p = .001), Cultural Identity (p = .033), and Economic Security (p = .041).

## Research Question 2

Is there a significant difference between (a) male and female engineering students, (b) undergraduate engineering students who have cooperative education (co-op) experiences and those who do not, (c) undergraduate engineering students who have engineering work experience and those who do not, and (d) engineering students who participate in undergraduate research and those who do not in terms of Personality types? Values factors?

### Males versus Females

Mean scores on the six personality types and five values factors for males and females can be seen in Table 2. When a MANOVA was conducted, significant differences between males and females with regard to personality types were found ($F(6,156) = 9.33$, $p < .001$). Individual ANOVAs seen in Table 3 indicated that males scored significantly higher on the Realistic ($F(1,161) = 27.44$, $p < .001$) and Investigative ($F(1,161) = 4.00$, $p = .047$) personality types while females scored significantly higher on

Table 2

Mean Scores on Personality Types and Values Factors by Gender

| | Gender | | | |
|---|---|---|---|---|
| | Male | | Female | |
| | Mean | Std. Deviation | Mean | Std. Deviation |
| Realistic* | 32.81 | 8.74 | 24.03 | 10.34 |
| Investigative* | 33.23 | 7.97 | 30.28 | 8.14 |
| Artistic | 18.08 | 9.79 | 20.31 | 8.81 |
| Social | 23.71 | 8.72 | 26.08 | 9.33 |
| Enterprising | 26.65 | 9.27 | 25.33 | 10.39 |
| Conventional* | 23.19 | 8.70 | 27.31 | 9.38 |
| Inner-Orientation | 15.30 | 1.92 | 15.18 | 1.75 |
| Group-Orientation | 13.92 | 2.17 | 14.55 | 2.30 |
| Material | 15.03 | 2.01 | 14.65 | 1.82 |
| Physical Prowess* | 11.21 | 2.62 | 10.05 | 2.46 |
| Physical Activity | 13.36 | 2.75 | 13.50 | 2.64 |

*. Statistically Significant

Table 3

ANOVAs of Gender by Personality Type

| | | Statistics | | |
|---|---|---|---|---|
| | | df | F | Sig. |
| GENDER | Realistic | 1, 161 | 27.437 | <.000 |
| | Investigative | 1, 161 | 4.004 | .047 |
| | Artistic | 1, 161 | 1.608 | .207 |
| | Social | 1, 161 | 2.114 | .148 |
| | Enterprising | 1, 161 | .560 | .455 |
| | Conventional | 1, 161 | 6.394 | .012 |

Table 4

ANOVAs of Gender by Values Factor

| | | Statistics | | |
|---|---|---|---|---|
| | | df | F | Sig. |
| GENDER | Inner-Orientation | 1, 159 | .109 | .742 |
| | Group-Orientation | 1, 159 | 2.288 | .132 |
| | Material | 1, 159 | 1.058 | .305 |
| | Physical Prowess | 1, 159 | 5.805 | .017 |
| | Physical Activity | 1, 159 | .076 | .782 |

the Conventional (F(1,161) = 6.39, p = .012) personality type. Another MANVOA also indicated significant differences between males and females with regard to values factors (F(5,155) = 2.79, p = .019). ANOVAs shown in Table 4 indicate that males scored significantly higher on the Physical Prowess (F(1,159) = 5.81, p = .017) factor than females.

Co-op versus No Co-op

Mean scores on the six personality types and five values factors for those who co-oped and those who did not co-op can be seen in Table 5. Two MANOVAs indicated that there were significant differences between those students who co-oped and those who did not with regard to personality types (F(6,157) = 2.94, p =.009) and values factors (F(5,156) = 2.75, p = .020). ANOVAs seen in Table 6 showed that those who did not co-op scored significantly higher on the Realistic (F(1,162) = 7.21, p = .008) personality type than those who co-oped and that those who did participate in a co-op experience scored significantly higher on the Conventional (F(1,162) = 7.69, p = .006) personality

Table 5

Mean Scores on Personality Types and Values Factors by Co-op Experience

| | Co-op Experience | | | |
|---|---|---|---|---|
| | Yes | | No | |
| | Mean | Std. Deviation | Mean | Std. Deviation |
| Realistic* | 28.08 | 9.95 | 32.25 | 9.47 |
| Investigative | 31.94 | 7.69 | 32.90 | 8.30 |
| Artistic | 17.68 | 8.59 | 19.17 | 10.10 |
| Social | 24.79 | 8.93 | 23.90 | 8.88 |
| Enterprising | 27.76 | 10.11 | 25.56 | 9.12 |
| Conventional* | 26.66 | 9.40 | 22.73 | 8.44 |
| Inner-Orientation | 15.04 | 1.84 | 15.40 | 1.89 |
| Group-Orientation | 14.25 | 2.24 | 13.96 | 2.18 |
| Material | 14.93 | 2.06 | 14.96 | 1.92 |
| Physical Prowess* | 10.33 | 2.37 | 11.31 | 2.70 |
| Physical Activity | 13.18 | 2.42 | 13.50 | 2.88 |

*. Statistically Significant

Table 6

ANOVAs of Co-op by Personality Types

| | | Statistics | | |
|---|---|---|---|---|
| | | df | F | Sig. |
| CO-OP | Realistic | 1,162 | 7.209 | .008 |
| | Investigative | 1,162 | .552 | .458 |
| | Artistic | 1,162 | .936 | .335 |
| | Social | 1,162 | .384 | .536 |
| | Enterprising | 1,162 | 2.065 | .153 |
| | Conventional | 1,162 | 7.690 | .006 |

Table 7

ANOVAs of Co-op by Values Factors

| | | Statistics | | |
|---|---|---|---|---|
| | | df | F | Sig. |
| CO-OP | Inner-Orientation | 1, 160 | 1.356 | .246 |
| | Group-Orientation | 1, 160 | .655 | .419 |
| | Material | 1, 160 | .008 | .928 |
| | Physical Prowess | 1, 160 | 5.467 | .021 |
| | Physical Activity | 1, 160 | .544 | .462 |

type than those students who did not participate in a co-op program. With regard to values factors, ANOVAs shown in Table 7 indicated that those who did not co-op scored significantly higher than those who did co-op on Physical Prowess ($F(1,160) = 5.47$, $p = .021$).

Engineering Work versus No Engineering Work

Mean scores on the six personality types and five values factors for those who have had engineering work experience and those who did not can be seen in Table 8. Two MANOVAs found no significant differences between students who participated in engineering work and those who did not with regard to personality types ($F(6,142) = 1.78$, $p = .107$) or values factors ($F(5,143) = .647$, $p = .664$).

Research versus No Research

Mean scores on the six personality types and five values factors for those who participated in undergraduate research and those who did not can be seen in Table 9. Two MANOVAs found no significant differences between students who participated in

Table 8

Mean Scores on Personality Types and Values Factors by Engineering Work Experience

| | Engineering Work Experience | | | |
|---|---|---|---|---|
| | Yes | | No | |
| | Mean | Std. Deviation | Mean | Std. Deviation |
| Realistic | 32.30 | 9.06 | 29.21 | 9.67 |
| Investigative | 33.69 | 7.81 | 32.02 | 8.19 |
| Artistic | 19.30 | 9.79 | 17.59 | 9.83 |
| Social | 25.33 | 8.55 | 22.43 | 8.72 |
| Enterprising | 28.05 | 9.50 | 24.11 | 9.20 |
| Conventional | 24.65 | 8.78 | 23.60 | 9.62 |
| Inner-Orientation | 15.52 | 1.86 | 15.06 | 1.92 |
| Group-Orientation | 14.08 | 2.07 | 14.03 | 2.50 |
| Material | 15.11 | 2.01 | 14.92 | 1.93 |
| Physical Prowess | 11.12 | 2.88 | 10.98 | 2.27 |
| Physical Activity | 13.50 | 2.84 | 13.30 | 2.67 |

Table 9

Means Scores on Personality Types and Values Factors by Undergraduate Research Experience

| | Undergraduate Research | | | |
|---|---|---|---|---|
| | Yes | | No | |
| | Mean | Std. Deviation | Mean | Std. Deviation |
| Realistic | 32.00 | 8.85 | 30.28 | 10.08 |
| Investigative | 35.35 | 8.42 | 31.85 | 7.92 |
| Artistic | 17.26 | 9.01 | 19.08 | 9.66 |
| Social | 25.16 | 10.14 | 24.08 | 8.63 |
| Enterprising | 26.90 | 9.51 | 26.36 | 9.62 |
| Conventional | 24.94 | 9.29 | 24.08 | 9.01 |
| Inner-Orientation | 15.19 | 1.84 | 15.29 | 1.90 |
| Group-Orientation | 13.50 | 1.86 | 14.20 | 2.27 |
| Material | 14.72 | 1.82 | 14.99 | 2.00 |
| Physical Prowess | 10.78 | 2.57 | 10.99 | 2.65 |
| Physical Activity | 12.81 | 2.82 | 13.53 | 2.69 |

research and those who did not with regard to personality types ($F(6,155) = 1.29$, $p = .263$) or values factors ($F(5,154) = .729$, $p = .603$).

## Research Question 3

Is there a significant difference between majors in undergraduate engineering fields offered at The University of Tennessee with regards to Personality types? Values factors? Due to the small number of students with senior standing within the fields of Aerospace Engineering (n=5), Engineering Physics (n=2), Material Science and Engineering (n=5), Computer Engineering (n=7), and Engineering Science (n=1) these fields were not included in the following analyses. Only Electrical (n=26), Civil (n=24), Chemical (n=27), Industrial (n=29), Biomedical (n=11), and Mechanical (n=27) Engineering fields were used to investigate research question three.

### Engineering Fields and Personality Types

Mean scores on the six personality types for Electrical, Civil, Chemical, Industrial, Biomedical, and Mechanical engineering fields can be seen in Table 10. A MANOVA indicated significant differences between fields with regard to personality types ($F(6, 133) = 2.987$, $p < .001$). Findings from individual ANOVAs seen in Table 11 indicated significant differences between fields with regard to the Realistic ($F(5, 138) = 4.02$, $p = .002$), Investigative ($F(5, 138) = 3.76$, $p = .003$), and Conventional ($F(5, 138) = 3.77$, $p = .003$) personality types. Results of post-hoc Tukey tests shown in Table 12 indicated that Mechanical engineering majors scored significantly higher on the Realistic personality type than Industrial ($p = .010$) and Biomedical ($p = .005$) engineering majors. The Tukey tests shown in Tables 13 and 14 also indicate that Industrial engineering

Table 10

Mean Scores on Personality Types by Engineering Fields

| | | Realistic | Investigative | Artistic | Social | Enterprising | Conventional |
|---|---|---|---|---|---|---|---|
| Electrical | Mean | 31.35 | 34.73 | 21.73 | 24.15 | 25.69 | 26.88 |
| | Std. Deviation | 9.03 | 6.86 | 9.71 | 8.27 | 10.31 | 9.17 |
| Civil | Mean | 32.75 | 29.67 | 15.63 | 24.83 | 29.08 | 21.38 |
| | Std. Deviation | 9.48 | 8.36 | 8.43 | 9.75 | 7.55 | 7.44 |
| Chemical | Mean | 28.63 | 34.15 | 17.78 | 24.15 | 24.81 | 24.48 |
| | Std. Deviation | 13.37 | 9.65 | 9.14 | 8.65 | 10.90 | 8.56 |
| Industrial | Mean | 27.14 | 28.14 | 20.76 | 27.10 | 31.52 | 28.79 |
| | Std. Deviation | 8.76 | 5.67 | 9.87 | 8.91 | 7.79 | 7.92 |
| Biomedical | Mean | 23.45 | 36.64 | 23.09 | 26.91 | 27.36 | 25.09 |
| | Std. Deviation | 6.46 | 8.52 | 11.08 | 8.36 | 4.63 | 11.34 |
| Mechanical | Mean | 35.78 | 32.00 | 17.56 | 23.07 | 25.67 | 20.37 |
| | Std. Deviation | 7.45 | 7.25 | 9.41 | 8.66 | 9.53 | 8.30 |

Table 11

ANOVAs of Engineering Field by Personality Type

| | Statistics | | |
|---|---|---|---|
| | df | F | Sig. |
| Realistic | 5, 138 | 4.022 | .002 |
| Investigative | 5, 138 | 3.760 | .003 |
| Artistic | 5, 138 | 1.859 | .106 |
| Social | 5, 138 | .785 | .562 |
| Enterprising | 5, 138 | 2.184 | .059 |
| Conventional | 5, 138 | 3.768 | .003 |

Table 12

Post Hoc Tests for Realistic Personality Type by Engineering Fields

| | | Statistics | |
| --- | --- | --- | --- |
| | | Mean Difference | Sig. |
| Electrical | Civil | -1.40 | .996 |
| | Chemical | 2.72 | .909 |
| | Industrial | 4.21 | .585 |
| | Biomedical | 7.89 | .202 |
| | Mechanical | -4.43 | .547 |
| Civil | Chemical | 4.12 | .647 |
| | Industrial | 5.61 | .280 |
| | Biomedical | 9.30 | .085 |
| | Mechanical | -3.03 | .872 |
| Chemical | Industrial | 1.49 | .992 |
| | Biomedical | 5.18 | .661 |
| | Mechanical | -7.15 | .069 |
| Industrial | Biomedical | 3.68 | .889 |
| | Mechanical | -8.63* | .010 |
| Biomedical | Mechanical | -12.32* | .005 |

Table 13

Post Hoc Tests for Investigative Personality Type by Engineering Fields

| | | Statistics | |
|---|---|---|---|
| | | Mean Difference | Sig. |
| Electrical | Civil | 5.06 | .186 |
| | Chemical | .58 | 1.000 |
| | Industrial | 6.59* | .019 |
| | Biomedical | -1.91 | .983 |
| | Mechanical | 2.73 | .791 |
| Civil | Chemical | -4.48 | .302 |
| | Industrial | 1.53 | .980 |
| | Biomedical | -6.97 | .129 |
| | Mechanical | -2.33 | .890 |
| Chemical | Industrial | 6.01* | .041 |
| | Biomedical | -2.49 | .946 |
| | Mechanical | 2.15 | .910 |
| Industrial | Biomedical | -8.50* | .023 |
| | Mechanical | -3.86 | .419 |
| Biomedical | Mechanical | 4.64 | .544 |

Table 14

Post Hoc Tests for Conventional Personality Type by Engineering Fields

| | | Statistics | |
|---|---|---|---|
| | | Mean Difference | Sig. |
| Electrical | Civil | 5.51 | .205 |
| | Chemical | 2.40 | .911 |
| | Industrial | -1.91 | .963 |
| | Biomedical | 1.79 | .992 |
| | Mechanical | 6.51 | .062 |
| Civil | Chemical | -3.11 | .789 |
| | Industrial | -7.42* | .021 |
| | Biomedical | -3.72 | .841 |
| | Mechanical | 1.00 | .998 |
| Chemical | Industrial | -4.31 | .412 |
| | Biomedical | -.61 | 1.000 |
| | Mechanical | 4.11 | .489 |
| Industrial | Biomedical | 3.70 | .827 |
| | Mechanical | 8.42* | .003 |
| Biomedical | Mechanical | 4.72 | .637 |

majors scored significantly lower on the Investigative personality type than Electrical (p = .019), Chemical (p = .041), and Biomedical (p = .023) engineering majors and that Industrial engineering majors also scored significantly higher on the Conventional personality type than Civil (p = .021) and Mechanical (p = .003) engineering majors. Plots of the mean scores on the Realistic, Investigative, and Conventional personality types across the six engineering fields can also be seen in Figures 1, 2, and 3.

<u>Engineering Fields and Values Factors</u>

Mean scores on the five values factors for Electrical, Civil, Chemical, Industrial, Biomedical, and Mechanical engineering fields can been seen in Table 15. A MANOVA did not indicate any significant differences between fields with regard to the values factors (F(25, 488) = 1.4, p = .096).

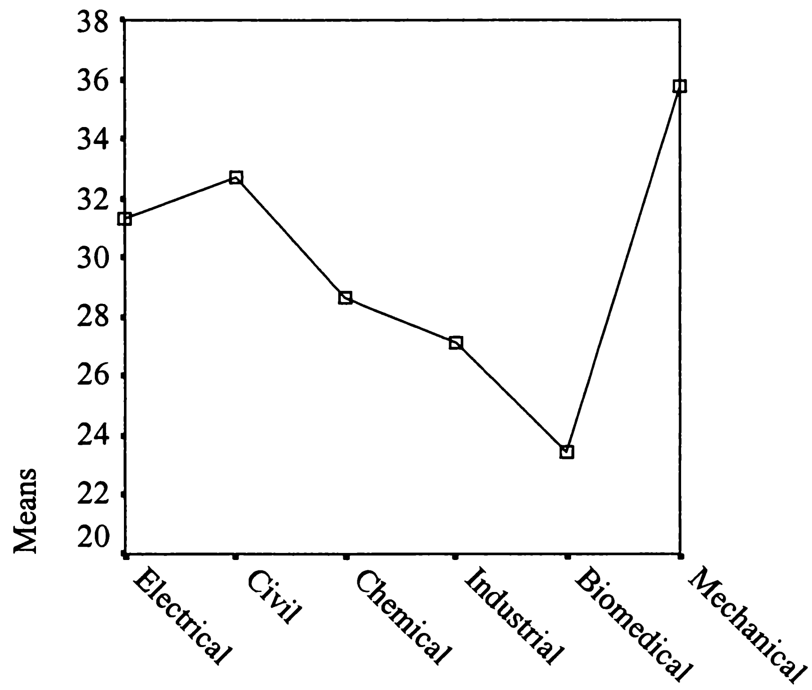


Figure 1: Means on Realistic Personality Type Across Engineering Fields

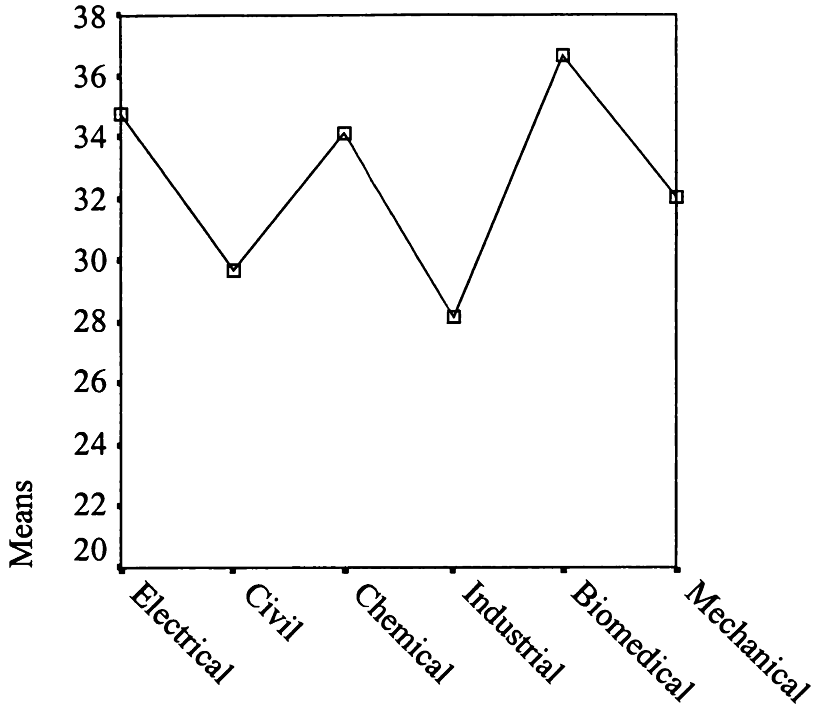


Figure 2: Means on Investigative Personality Type Across Engineering Fields

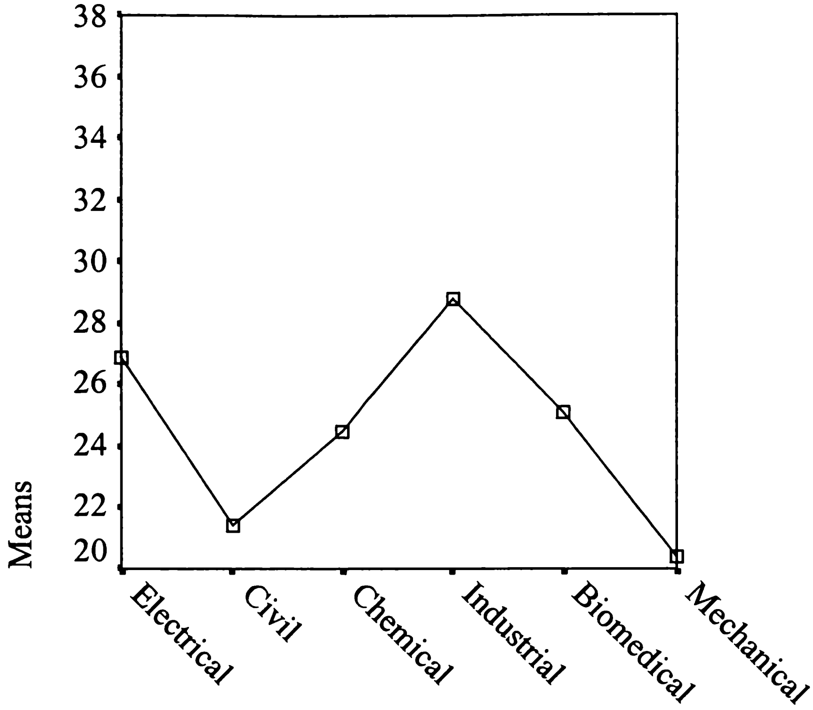


Figure 3: Means on Conventional Personality Type Across Engineering Fields

Table 15

Mean Scores on Values Factors by Engineering Fields

| | | Inner-Orientation | Group-Orientation | Material | Physical Prowess | Physical Activity |
|---|---|---|---|---|---|---|
| Electrical | Mean | 15.22 | 13.96 | 15.36 | 11.09 | 13.21 |
| | Std. Deviation | 1.46 | 1.73 | 1.91 | 1.54 | 2.55 |
| Civil | Mean | 15.35 | 13.97 | 15.25 | 11.75 | 14.48 |
| | Std. Deviation | 1.76 | 1.94 | 1.93 | 3.14 | 2.33 |
| Chemical | Mean | 15.37 | 14.69 | 14.95 | 10.57 | 13.02 |
| | Std. Deviation | 2.07 | 2.17 | 2.25 | 2.65 | 2.48 |
| Industrial | Mean | 15.85 | 14.92 | 15.62 | 11.57 | 14.10 |
| | Std. Deviation | 2.11 | 2.45 | 2.13 | 2.84 | 3.01 |
| Biomedical | Mean | 15.65 | 13.88 | 14.03 | 9.55 | 12.73 |
| | Std. Deviation | 2.22 | 3.22 | 2.30 | 2.46 | 2.52 |
| Mechanical | Mean | 14.64 | 13.68 | 14.46 | 10.79 | 13.37 |
| | Std. Deviation | 1.76 | 2.02 | 1.45 | 2.74 | 2.65 |

## Additional Analyses

After analyzing research question three by Personality types and Values factors, analyses were conducted across fields of engineering. This perspective gives a view of the findings by each field in addition to the previous analyses by Personality types and Values factors.

### Differences in Personality Types Across All Engineering Fields

Single Repeated Measures ANOVAs indicated a significant interaction among undergraduate engineering fields and personality types ($F(5, 139) = 47.613$, $p < .000$). A plot of the means can be seen in Figure 4.

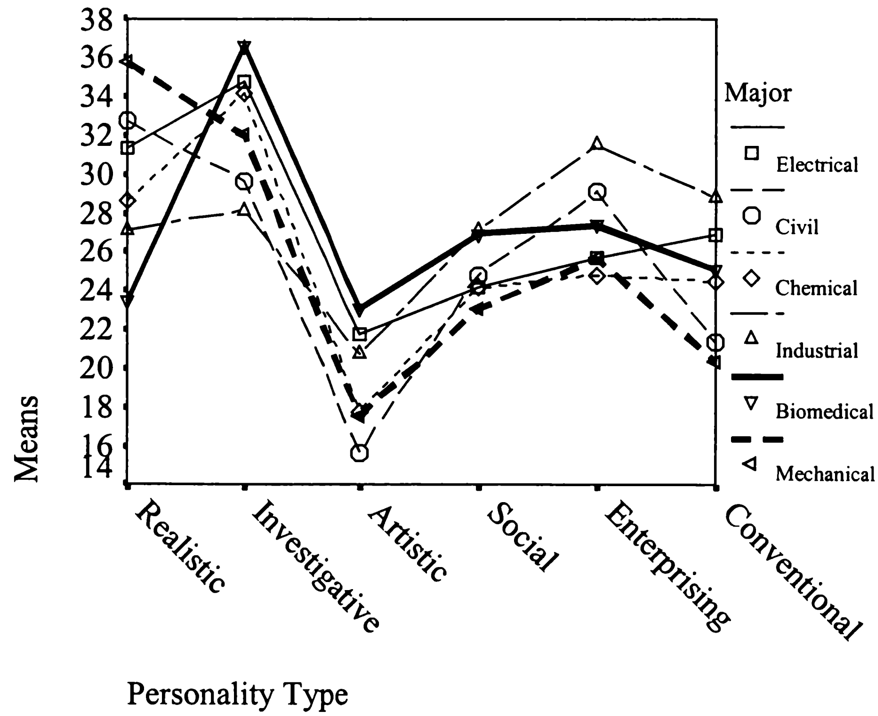


Figure 4: All Engineering Fields' Means on Personality Types

Differences in Personality Types Across Each Engineering Field

Single Repeated Measures ANOVAs were performed to investigate the differences among the six personality types by the six engineering fields. A significant interaction indicated that the personality types varied differently for the fields. Because of the significant interaction the differences within the fields was investigated. Repeated measures ANOVAs for each field indicated significant findings except that there were no significant differences between personality types for the Biomedical engineering major. Post hoc analyses were conducted for each engineering field and the following results were found.

For the Electrical engineering major, the mean for the Realistic personality type was found to be significantly higher than Artistic ($p = .005$) and the mean for the Investigative personality type was significantly higher than Artistic ($p < .001$), Social ($p < .001$), Enterprising ($p = .001$), and Conventional ($p = .002$). The plot of the means can be seen in Figure 5.

The plot of the means for the Civil engineering major can be seen in Figure 6. The mean for the Artistic personality type was significantly lower than Realistic ($p < .001$), Investigative ($p < .001$), Social ($p < .001$), and Enterprising ($p < .001$) and the mean for the Conventional personality type was significantly lower than Realistic ($p = .001$), Investigative ($p = .014$), and Enterprising ($p = .003$).

For the Chemical engineering major, the mean for the Investigative personality type was significantly higher than Social ($p < .001$), Enterprising ($p = .001$), and Conventional ($p < .001$) and the Artistic personality type was significantly lower than Realistic

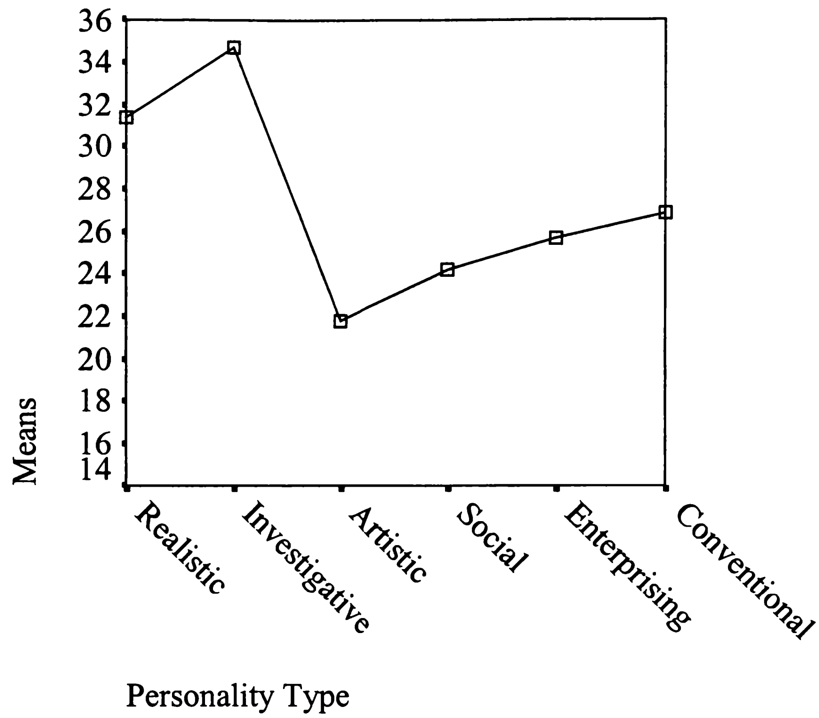


Figure 5: Means on Personality Types for Electrical Engineering Majors

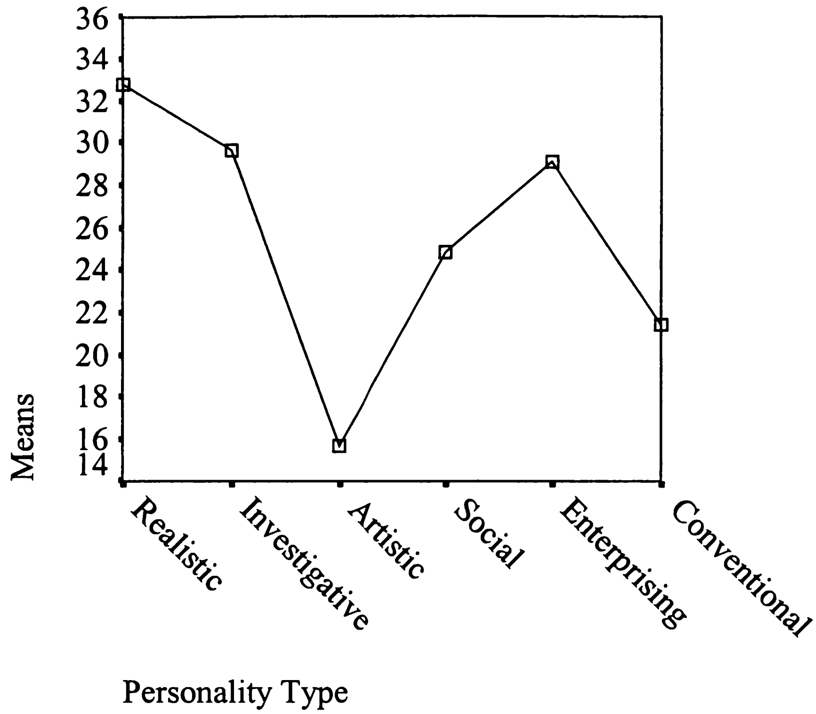


Figure 6: Means on Personality Types for Civil Engineering Majors

(p = .014), Investigative (p < .001), Social (p = .025), Enterprising (p = .036), and Conventional (p = .025). The plotted means can be seen in Figure 7.

For the Industrial engineering major, the mean for the Artistic personality type was significantly lower than Investigative (p = .010), Enterprising (p = .001), and Conventional (p = .015). See Figure 8 for a plot of the means.

Finally, for the Mechanical engineering major, the mean for the Realistic personality type was significantly higher than Social (p < .001), Enterprising (p = .001), and Conventional (p < .001); the Investigative personality type was significantly higher than Social (p < .001), and Conventional (p < .001); the Artistic personality type was significantly lower than Realistic (p < .001), Investigative (p < .001), and Enterprising (p = .041); and the Enterprising personality type was significantly higher than Conventional (p = .026). A plot of the means can be seen in Figure 9.

<u>Differences in Values Factors Across All Engineering Fields</u>

Single Repeated Measures ANOVAs indicated a significant interaction among undergraduate engineering fields and values factors ($F(4, 137) = 133.767$, $p < .000$). A plot of the means can be seen in Figure 10.

<u>Differences in Values Factors Across Each Engineering Field</u>

Single Repeated Measures ANOVAs were performed to investigate the differences among the five values factors by the six engineering fields. The analyses indicated a significant interaction meaning that the values factors varied differently for each field. Because a significant interaction was found, the differences between the engineering fields were explored. Repeated measures ANOVAs for each field indicated significant

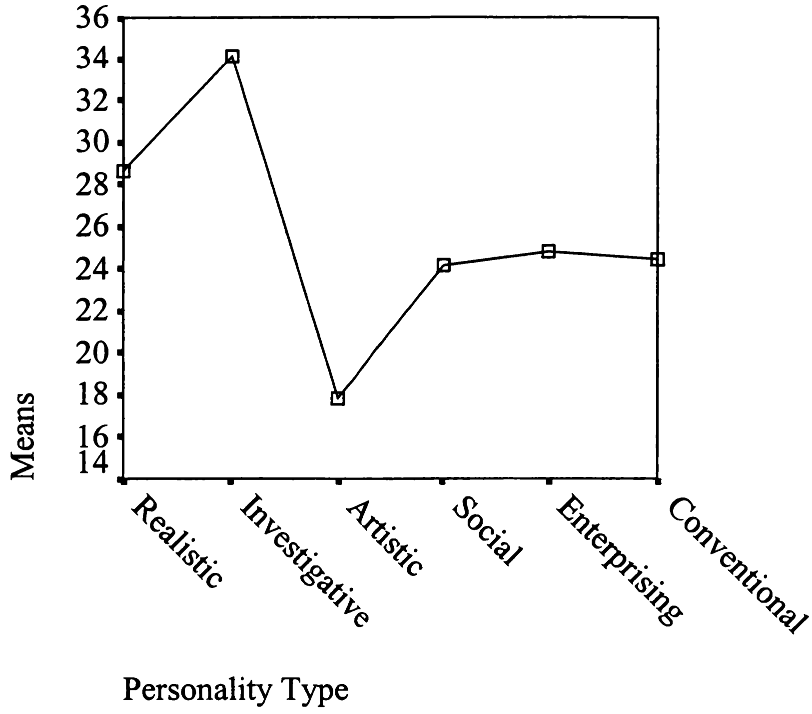


Figure 7: Means on Personality Types for Chemical Engineering Majors

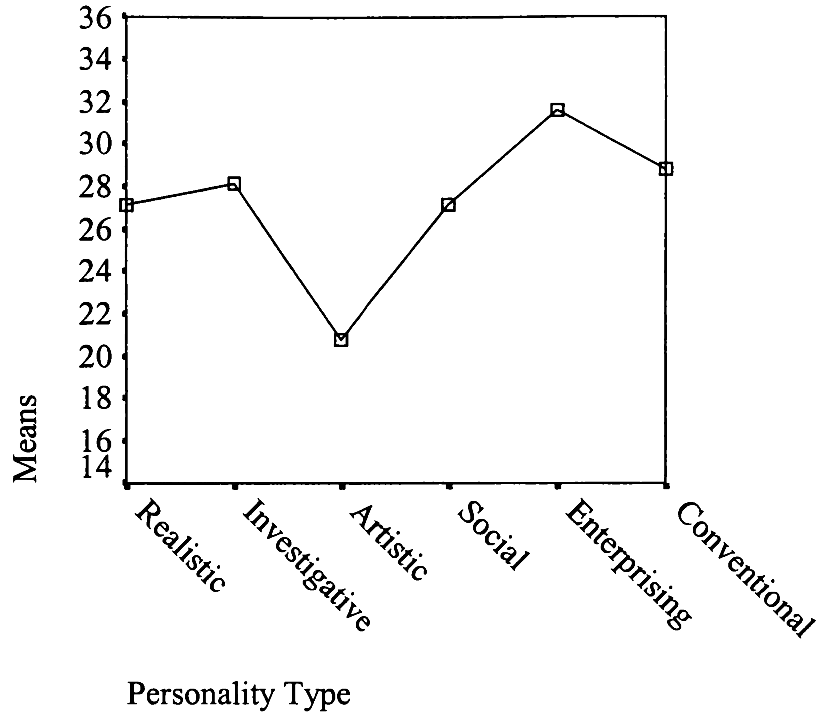


Figure 8: Means on Personality Types for Industrial Engineering Majors

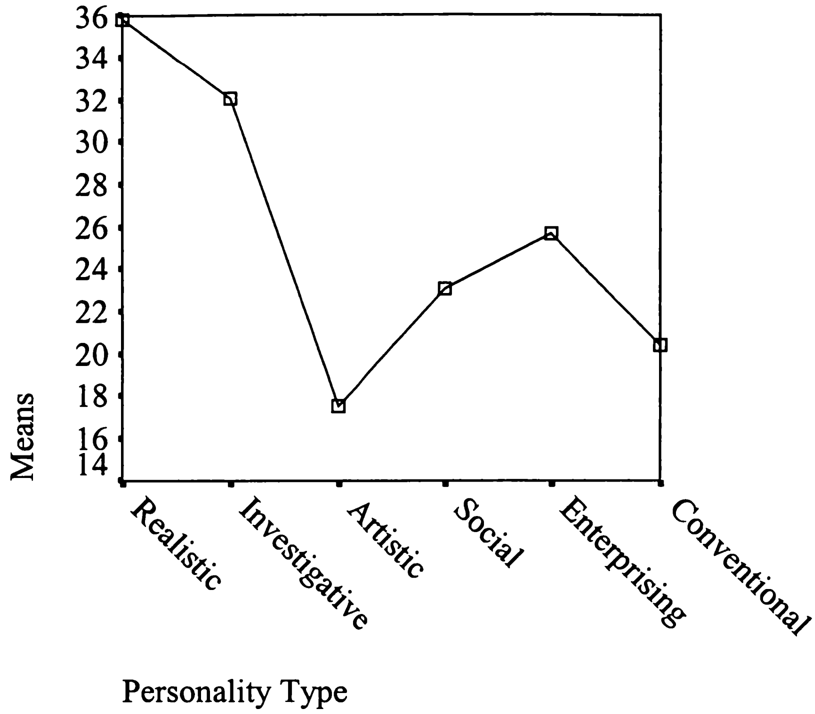


Figure 9: Means on Personality Types for Mechanical Engineering Majors

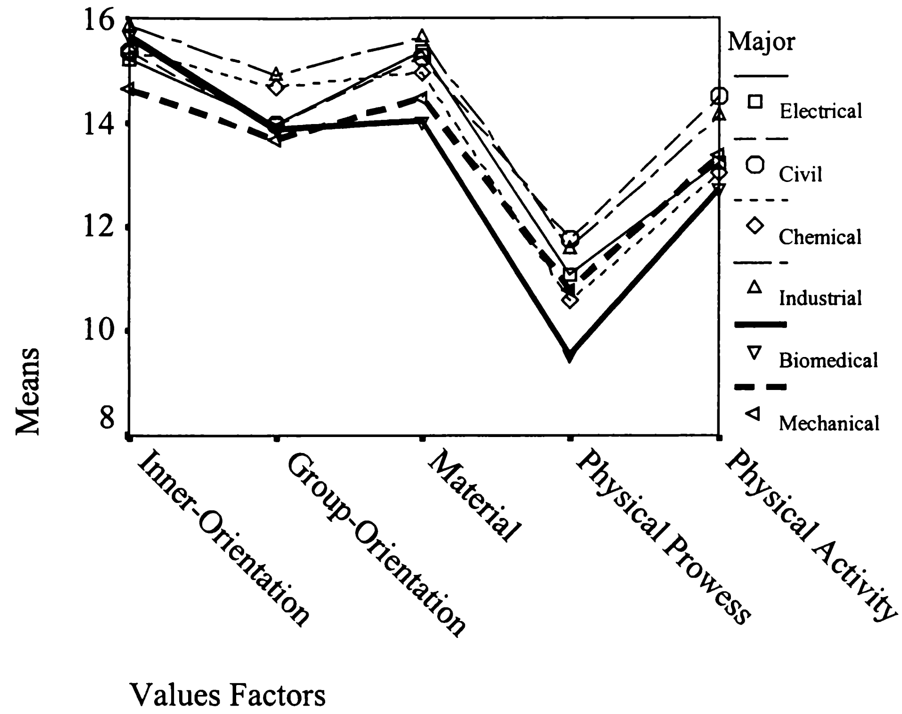


Figure 10: All Engineering Fields' Means on Values Factors

findings. Post hoc analyses were conducted for each field and the following results were found.

For the Electrical engineering major, the mean for the Inner-Orientation factor was significantly higher than Group-Orientation ($p = .011$) and Physical Activity ($p = .005$); the Material factor was significantly higher than Group-Orientation ($p = .048$) and Physical Activity ($p = .011$); and the Physical Prowess factor was significantly lower than Inner-Orientation ($p < .001$), Group Orientation ($p < .001$), Material ($p < .001$), and Physical Activity ($p = .002$). A plot of the means can be seen in Figure 11.

For the Civil engineering major, the mean for the Inner-Orientation factor was significantly higher than Group-Orientation ($p = .002$) and the Physical Prowess factor was significantly lower than Inner-Orientation ($p < .001$), Material ($p < .001$), and Physical Activity ($p = .005$). The plots of the means can be seen in Figure 12.

For the Chemical engineering major, the mean for the Physical Prowess factor was significantly lower than Inner-Orientation ($p < .001$), Group-Orientation ($p < .001$), Material ($p < .001$), and Physical Activity ($p < .001$) and the Physical Activity factor was significantly lower than Inner-Orientation ($p < .001$), Group-Orientation ($p = .003$), and Material ($p = .002$). See Figure 13 for a plot of the means.

For the Industrial engineering major, the mean for the Inner-Orientation factor was significantly higher than Physical Activity ($p = .005$) and the Physical Prowess factor was significantly lower than Inner-Orientation ($p < .001$), Group-Orientation ($p < .001$), Material ($p < .001$), and Physical Activity ($p < .001$). A plot of the means can be seen in Figure 14.

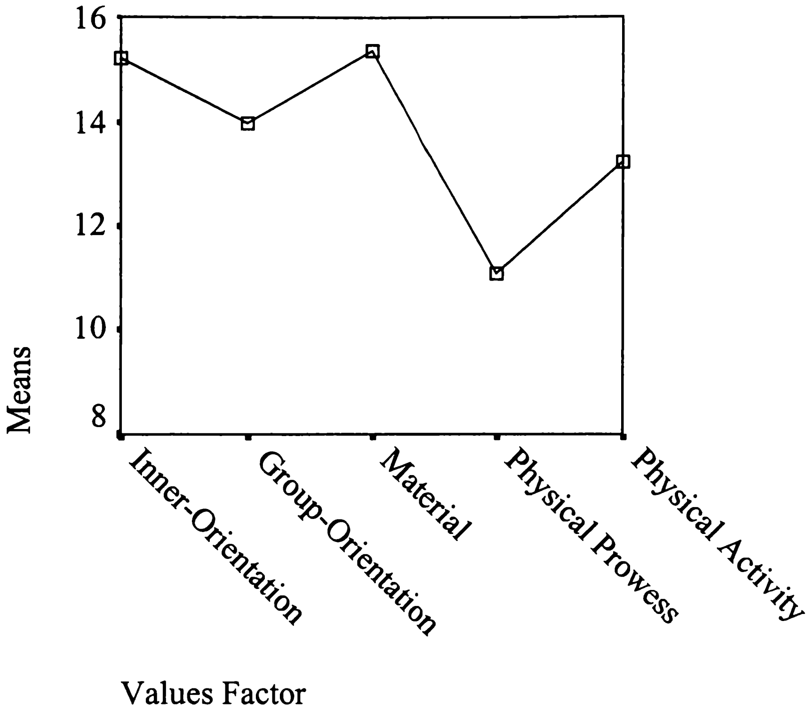


Figure 11: Means on Values Factors for Electrical Engineering Majors

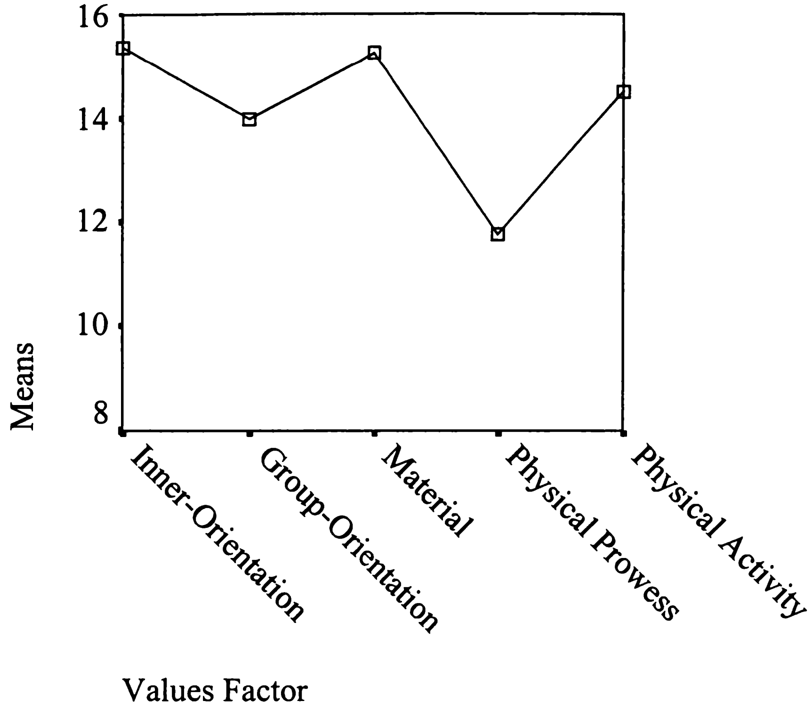


Figure 12: Means on Values Factors for Civil Engineering Majors

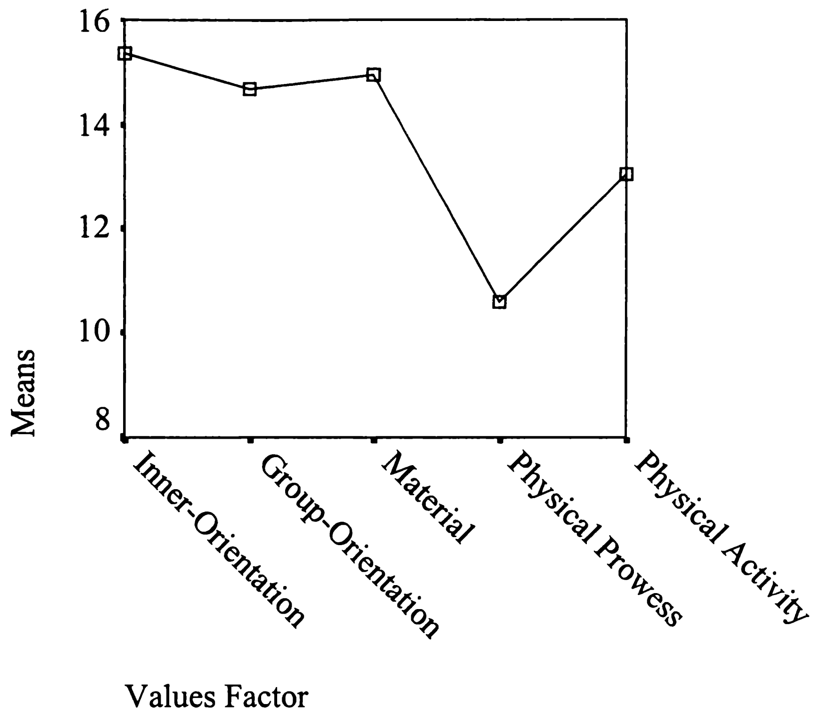


Figure 13: Means on Values Factors for Chemical Engineering Majors

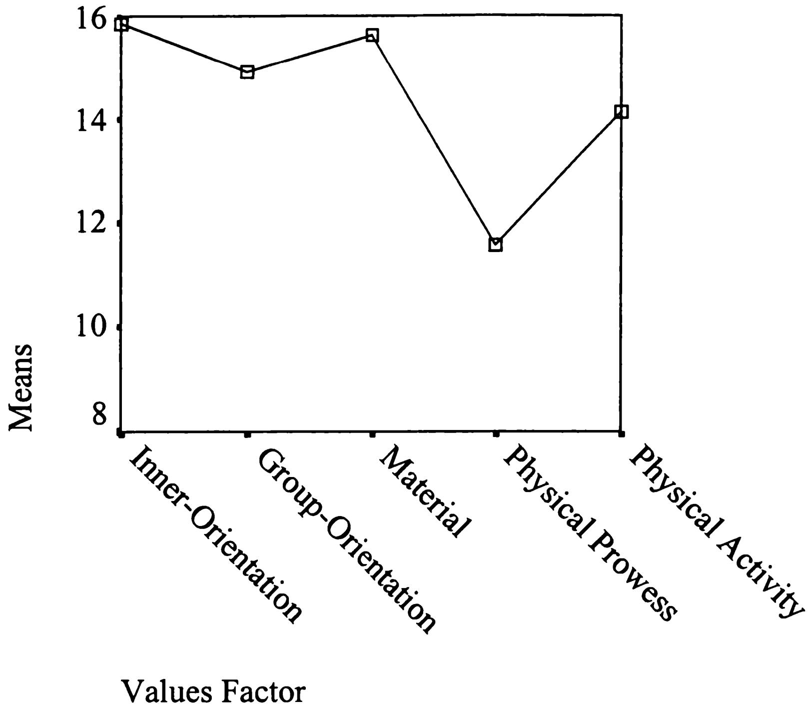


Figure 14: Means on Values Factors for Industrial Engineering Majors

For the Biomedical engineering major the mean for the Inner-Orientation factor was significantly higher than Physical Activity ($p = .003$) and the Physical Prowess factor was significantly lower than Inner-Orientation ($p < .001$), Group-Orientation ($p = .002$), Material ($p < .001$), and Physical Activity ($p = .014$). Figure 15 displays a plot of the means.

Finally, for the Mechanical engineering major, the mean for the Inner-Orientation factor was significantly higher than Group-Orientation ($p = .022$) and Physical Activity ($p = .021$) and the Physical Prowess factor was significantly lower than Inner-Orientation ($p < .001$), Group-Orientation ($p < .001$), Material ($p < .001$), and Physical Activity ($p < .001$). A plot of the means can be seen in Figure 16.

## Summary of Findings

There were several significant results of the correlation of the six personality types with the 21 values. As the scores for the Realistic personality type increased the scores for the values Creativity, Physical Activity, Risk, and Physical Prowess also increased. As the scores for the Investigative personality type increased the scores for the values for Achievement, Creativity, Personal Development, and Risk also increased. As the scores for the personality type Artistic increased, so did the scores for the values Achievement, Aesthetics, Altruism, Creativity, Personal Development, Prestige, Social Interaction, Variety, Working Conditions. However the scores for the value Economic Rewards decreased as the scores for Artistic increased. As the scores for the Social personality type increased the score for the values Aesthetics, Altruism, Personal Development, Prestige, Social Interaction, Social Relations, Variety, and Cultural Identity also increased while Economic Rewards and Economic Security decreased. As the scores for

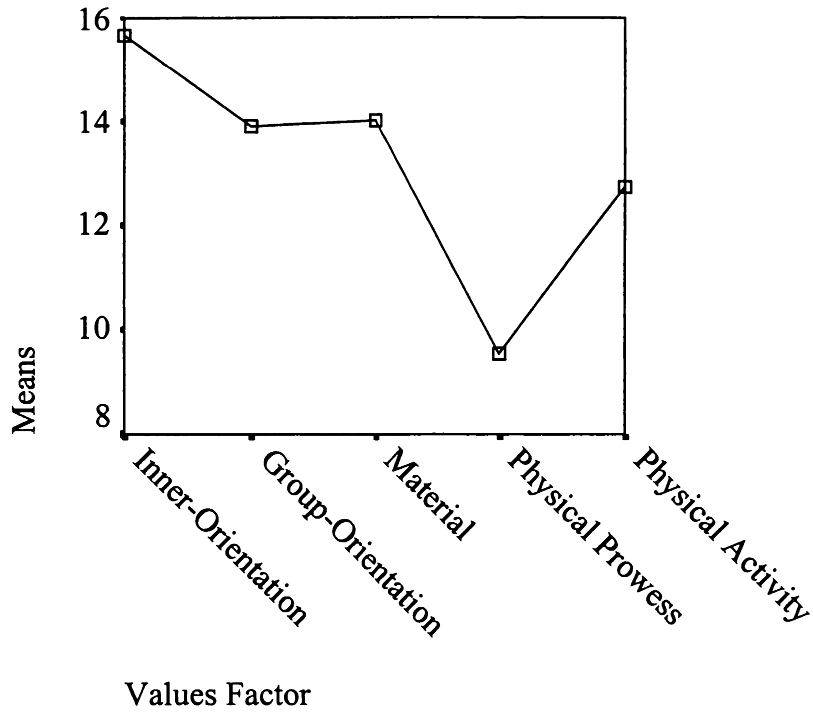


Figure 15: Means on Values Factors for Biomedical Engineering Majors

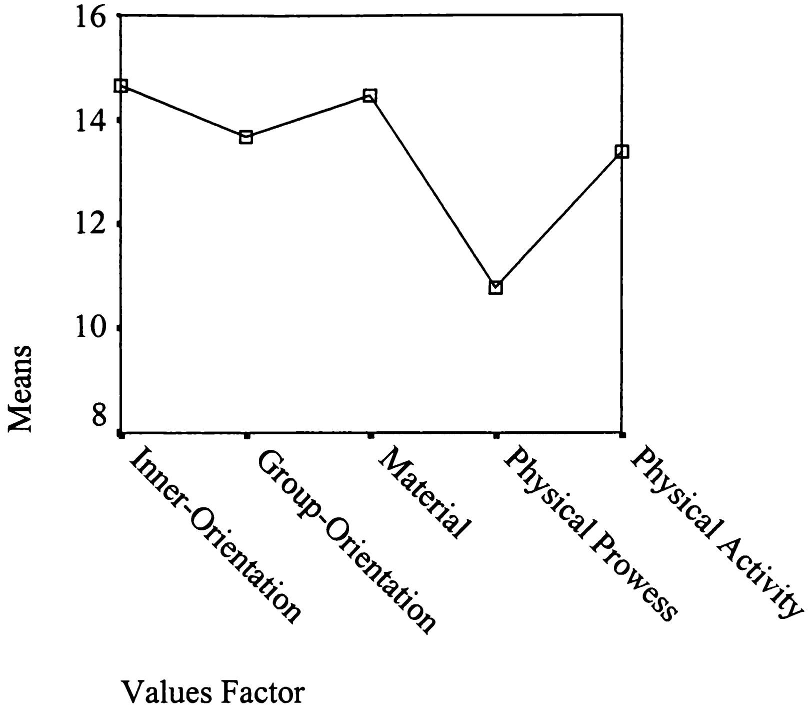


Figure 16: Means on Values Factors for Mechanical Engineering Majors

the Enterprising personality type increased, so did the score for the values Advancement, Authority, Autonomy, Personal Development, Physical Activity, Prestige, Risk, Social Interaction, Social Relations, and Variety. Lastly, as the scores for the personality type Conventional increased the scores for the values Achievement, Advancement, Authority, Working Conditions, Cultural Identity, and Economic Security also increased.

There were a number of significant findings with regard to gender and personality types as well as gender and values factors. Males scored significantly higher on the Realistic and Investigative personality types as well as the Physical Prowess values factor while females scored significantly higher on the Conventional personality type.

There were several significant findings with regard to co-oping and personality types as well as co-oping and values factors. Those who did not co-op scored significantly higher on the Realistic personality type and the Physical Prowess values factor than those who co-oped. Those who did participate in a co-op experience scored significantly higher on the Conventional personality type than those students who did not participate in a co-op program. There were no significant findings with regard to engineering work experience and personality types or values factors, and research participation and personality types or values factors.

Significant findings with regard to engineering fields and personality type were also found. Mechanical engineering majors scored significantly higher on the Realistic personality type than Industrial and Biomedical engineering majors. Industrial engineering majors scored significantly lowered on the Investigative personality type than Electrical, Chemical, and Biomedical engineering majors and they scored significantly higher on the Conventional personality type than Civil and Mechanical engineering majors.

Finally, additional analyses indicated that the Realistic and Investigative personality types had the highest means while Artistic had the lowest means for all six fields combined and for Electrical, Civil, Chemical, and Mechanical engineering majors individually. However, for Industrial engineering majors, only the mean scores for Artistic were found to be significantly lower than all other personality types, while the mean scores for Enterprising were higher than Realistic and Investigative, although not significantly so.

When analyzing the values factors across engineering fields, there were small significant differences among the fields, however the common significant finding was that the Physical Prowess factor had the lowest mean score for all fields.

A review of the definition of terms for this study and a list of significant findings were presented in Chapter IV. A further description and explanation of the results, a discussion of what the results mean for career counselors and academic advisors, and a list of possible future studies that might expand on the present findings will be presented in Chapter V.

# CHAPTER V

# DISCUSSION

This chapter will explore and expand on the results presented in Chapter IV. The intent of the present study as well as the research questions will be reviewed, a description and possible explanation of the results will be presented, the importance and practical use of the results will be listed, limitations of the results will be noted, and ideas for future research will be discussed.

## The Present Study

As discussed earlier, previous research on the interests and values of engineering students, have produced two themes: (a) there is disagreement on whether interests and values are two separate constructs and (b) although there are studies that compare the interests and values of engineering students and professional engineers to other college majors and occupations, no studies have been found which focus on the relationship of interests and values in the fields of engineering. These two themes, coupled with the increased demand for engineering professionals, established the need for conducting a study that could result in information to assist career counselors and academic advisors when working with engineering students on their career decision making process.

The research questions that were examined include:

1. What is the relationship between values of undergraduate engineering students as measured by the Values Scale and their personality types as measured by the Self-Directed Search?
2. Is there a significant difference between (a) male and female engineering students, (b) undergraduate engineering students who have cooperative education (co-op)

experiences and those who do not, (c) undergraduate engineering students who have engineering work experience and those who do not, and (d) engineering students who participate in undergraduate research and those who do not in terms of Personality types? Values factors?

3. Is there a significant difference between majors in undergraduate engineering fields offered at The University of Tennessee with regards to Personality types? Values factors?

## Results

### Research Question 1

Most of the findings that corresponded to the first research question in the present study were expected. The authors of the Values Scale manual (Nevill & Super, 1989) predicted which values would be related to which personality types. The results of the correlation matrix were similar to their predictions, however there were some differences and additions. The Realistic personality type prefers systematic or ordered manipulation of tools, animals, objects, and machines which leads to competencies in technical, mechanical, agricultural, and electrical fields (Holland, 1997). For the engineering sample in this study, the Realistic type was related to the Physical Prowess and Physical Activity values as predicted in the Values Scale manual (Nevill & Super, 1989). However, the Realistic type was also related to the values of Creativity and Risk. While these two values may not be predicted to be related to the Realistic personality type in the overall population, the definitions of these two values help one to understand why they would be significantly related to the Realistic personality type for engineering students. Creativity is defined as discovering, developing, or designing new things which engineering students must do when working on projects. Risk is defined as risky behavior. Engineering students must be able to take risks in order to try something different which in turn might make a product or project better.

The Investigative personality type prefers systematic observational, and creative investigation of cultural, biological, and physical fields of study and leads to competencies in science and mathematics (Holland, 1997). The Investigative type was related to the values Achievement, Creativity, Personal Development, and Risk in the present study; however, this was not predicted by Nevill and Super (1989). They predicted that the Investigative type would be related to Autonomy because this type tends to be analytical, precise, and methodical. However, Achievement is defined as having results that indicate doing well, Creativity is defined as discovering, developing, or designing new things, Personal Development is defined as development as a person, and Risk is defined as risky behavior. The relationship of these values to the Investigative personality type can be explained because the field of engineering revolves around taking creative risks to develop new products.

The Artistic personality type has competencies in areas such as language, sculpting, music, drama, or writing because of preferences for activities that call for manipulation of verbal, physical, or human materials to create forms or products of art (Holland, 1997). The Artistic type was related to Aesthetics and Creativity which was expected according to the Values Scale manual (Nevill & Super, 1989). The Artistic type was also related to Altruism, Personal Development, Prestige, Social Interaction, Variety, and Working Conditions, and negatively related to Economic Rewards. For this engineering sample, the relationship between the values of Variety and Working Conditions and the Artistic type might be explained by the definitions of these values. Variety is defined as having every day be different and Working Conditions is defined as having good light and space in which to work. These two values may be important to an engineer who indicates an interest in the Artistic personality type. It might also be important to engineers with an Artistic personality type to develop as a person as indicated by higher scores on the Personal Development value and not be so concerned with Economic Rewards as indicated by lower scores on that value. However, it is more difficult to explain the relationship between the values Altruism, Prestige, and Social Interaction with the Artistic personality type for this engineering sample.

The Social personality type prefers dealing with others in ways such as informing, training, curing, or enlightening so that they develop competencies in human relations (Holland, 1997). The Social type was related to Social Interaction and Social Relations as predicted by Nevill and Super (1989). However, it was also related to Aesthetics, Altruism, Personal Development, Prestige, Variety, and Cultural Identity and was negatively related to Economic Rewards. Altruism is defined as helping people with problems, Personal Development is defined as developing as a person, and Cultural Identity is defined as living where people of one's religion or race are accepted. These values would intuitively be important to someone who has a high score on the Social personality type. It is also understandable how those who show an interest in the Social personality type also do not value Economic Rewards. Perhaps they prefer the benefits of helping others to monetary outcomes. However the relationships between the values Aesthetics, Prestige, and Variety and the Social personality type are less clear.

The Enterprising personality type prefers working with others for economic gain and organizational goals that leads to competencies in leadership and persuasion (Holland, 1997). The Enterprising type was related to Advancement, Authority, Autonomy, Personal Development, Physical Activity, Prestige, and Variety. None of these relationships were predicted in the Values Scale manual (Nevill & Super, 1989). The manual predicted that the Enterprising type would be related to Economic Rewards. The relationship of this personality type with Personal Development, Physical Activity, and Variety is unclear. However, the definitions of Advancement, Authority, Autonomy, and Prestige fit with the description of this personality type. Advancement is getting ahead; Authority is telling others what to do; Autonomy is acting on one's own, and Prestige is being admired for knowledge and skills. Thus, the relationship between the Enterprising personality type and these latter values can be better understood through analyzing the description of the values and the personality type.

Finally, the Conventional personality type prefers to work with data in a systematic, explicit, and ordered way which tends to lead to competencies in clerical, computational, and business fields (Holland, 1997). The Conventional type was related to Economic Security which was predicted by Nevill and Super (1989). It was also related to Achievement, Advancement, Authority, Working Conditions, and Cultural Identity. While the relationship of the Conventional personality type and the values of Authority and Cultural Identity is not clear, the definitions of the values Achievement, Advancement, and Working Conditions help one understand the relationship. Achievement is defined as having results that indicate doing well; Advancement is getting ahead; and Working Conditions is defined as having good space and light in which to work. For this sample of engineering students, each of these values may be important to an engineer with the Conventional personality type.

Research Question 2

The second research question was aimed at exploring whether or not different experiences would create differences in scores on the personality types as well as the values factors. Gender, co-oping, engineering work experience, and research were examined for this question.

Gender.

For gender, males' mean scores were higher for the Realistic and Investigative personality types than females, while females' mean scores were higher for the Conventional personality type than males. According to Holland's (1997) description of the six personality types, these findings indicate that male engineering students tend to be more hardheaded, uninsightful, robust, and materialistic as described by the Realistic personality type and more analytical, critical, independent, and rational as described by the Investigative personality type. However, females tend to be more conscientious, efficient, orderly, and thorough as described by the Conventional personality type. While there are differences among these personality types, it is also important to point out the similarities in descriptors between these three types as noted by Holland (1997). Holland (1997) uses the following descriptors for both the Realistic and Conventional types: conforming, dogmatic, inflexible, persistent, and practical. He also uses the word "cautious" to describe the Investigative type and the word "careful" to describe the Conventional type. Therefore the similarities between these three types should not be overlooked. Thus, while it is important to know that male engineering students tend to score higher on the Realistic and Investigative personality types than females, it may be more important to know that female engineering students tend to score higher on the Conventional personality type than males. This finding could be important because advisors and counselors might discourage females, who do not score high on the Realistic or Investigative types, from entering into engineering because Realistic and Investigative personality types are the most common in the engineering fields, according to Holland's (1997) personality profiles.

Males scored higher on the Physical Prowess values factor, meaning that males thought that it was more important to work hard physically than females did. This result is similar to the findings in studies of other groups such as military personnel and high school students, discussed in the Values Scale manual (Nevill & Super, 1989).

Co-oping.

Students who co-oped had higher mean scores on the Conventional personality type than those who did not co-op. However, those who did not co-op had higher mean scores on the Realistic personality type and the Physical Prowess values factor. It may be easier to understand the differences in scores on the Realistic and Conventional personality types by first looking at the similarities between the types. Holland (1997) lists a number of descriptors for each of his six personality types. The Realistic and Conventional share many of the same descriptors such as: conforming, dogmatic, practical, and persistent. Where the two appear to differ the most is the business-mindedness of the Conventional personality type. Those who have participated in a co-op program have experienced the world of work in the engineering field and thus perhaps have a better understanding of how his or her engineering knowledge will be put to use in the working world. Some of the other words that Holland (1997) used to describe the Conventional type were orderly, efficient, and thorough. These qualities are certainly needed in the business world. Perhaps this helps to explain why engineering students who have not co-oped have higher scores on the Realistic personality type and those who have co-oped scored higher on the Conventional type. While the two types have many similarities, perhaps it is the business-mindedness of the Conventional type which makes the co-op participants different from their peers. Whether co-oping affected scores on the personality types or whether the Conventional types tend to choose co-op experiences is unknown because there was no pre-testing prior to the co-oping experience of the participants in this study.

The fact that the students who did not co-op also scored higher on the Physical Prowess values factor, meaning that they indicated they valued working hard physically, might be explained by the fact that as students, engineering majors follow a project from paper to the product. Because of their exposure to the world of work, those students who have experienced a co-op program may have a better understanding that there are engineers at all levels of product development. He or she may be involved with the brain-work behind a product but may or may not work physically on the project.

Engineering work experience and research.

There were no significant differences between those who participated in an engineering work experience and those who did not. This finding may be because the engineering work experience was not structured like a co-op program. Engineering work experience was defined as students who worked in the engineering field part time during the school year or part time or full time during the summer or holiday breaks. During a typical co-op experience students work full time and only a few students choose to also take classes. Thus, the co-op and engineering work experiences are not the same. There were also no significant differences between those who participated in undergraduate research and those who did not. Because there were only 30 students in this study who indicated that they participated in research as an undergraduate, this finding may need to be explored with a larger sample.

Research Question 3

The third research question investigated the differences between the Electrical, Civil, Chemical, Industrial, Biomedical, and Mechanical undergraduate engineering majors on the personality types and values factors. There were no significant differences between engineering fields on the Artistic, Social, and Enterprising personality types. However, there were significant differences in mean scores between the engineering fields on the Realistic, Investigative, and Conventional types.

According to *The College Majors Finder* (Rosen, Holmberg, & Holland, 1989), a reference guide often used to assist individuals who complete the SDS, the three letter personality profiles that correspond to each of the six engineering fields that were investigated in the present study are as follows: Mechanical: RIS; Industrial: EIR; Biomedical: IRE; Civil: IRE; Chemical: IRS; and Electrical: RIE. Holland's "rule of 8" states that if the scores for the individual personality types that make up a personality profile are within 8 of each other then they are within the limits of measurement error and their order in the profile can be switched (Holland, 1985). In the present study, even when using the "rule of 8" suggested by Holland, there were too many profiles represented within each engineering field. For example, one student's scores on the personality types was 32 – Enterprising, 25 – Investigative, 23 – Social, 14 – Conventional, 6 – Realistic, and 5 – Artistic. This meant that when using the "rule of 8" this student's personality profile could have been EIS, IES, or ESI. However, even after using this procedure over 30 profiles were still found. Thus, analyses were conducted which focused on each of the six personality types for each engineering field in this sample. The significant differences between fields regarding the Realistic, Investigative, and Conventional personality types can be explored by referring to the personality profiles listed above that correspond to the six engineering fields.

For the Realistic personality type, the Mechanical engineering major scored higher than the Industrial and Biomedical majors, but did not differ from the Civil, Chemical, or Electrical majors. According to *The College Majors Finder* (Rosen, Holmberg, & Holland, 1989), the Realistic type is listed in the primary position for the Mechanical engineering major (RIS), in the secondary position for the Biomedical engineering major (IRE), and in the third position for the Industrial engineering major (EIR). Therefore, the mean score for the Realistic personality type would be expected to be higher for the Mechanical major than for the Industrial or Biomedical major. It is also understandable that the Electrical engineering major (RIE) did not differ significantly from the Mechanical major on the Realistic personality type. Both fields of engineering share the Realistic type in the primary position for their personality profile. However, it is interesting that the Civil (IRE) and Chemical (IRS) engineering majors did not differ significantly from the Mechanical major on the Realistic personality type. Both Civil and Chemical majors share the Realistic type in the secondary position of their personality profiles whereas the Mechanical engineering major had the Realistic type in the primary position of its personality profile.

For the Investigative personality type, the Industrial major scored lower than the Electrical, Chemical, and Biomedical engineering majors, but did not differ from the Mechanical or Civil majors. This finding coincides with most of the personality profiles indicated in *The College Majors Finder* (Rosen, Helmberg, & Holland, 1989). For the Industrial engineering major, the Investigative personality type falls in the second position of the personality profile for this major. The fact that the Industrial major (EIR) scored lower on the Investigative type than the Chemical (IRS) and Biomedical (IRE) majors is understandable due to the positioning of the Investigative type in the personality profiles that correspond to these fields of engineering. It also makes sense that the Industrial major (EIR) did not differ from the Mechanical major (RIS) since both majors share the Investigative type in the second position of their personality profiles. However, it is interesting that the Industrial major differed from the Electrical major (RIE) when they share the Investigative type in the same position. It is also interesting that the Industrial major did not differ from the Civil major (IRE) when the Investigative type should have received a higher score for the Civil engineering major than the Industrial major, according to *The College Majors Finder* (Rosen, Helmberg, Holland, 1989).

For the Conventional personality type, the Industrial major scored higher than the Mechanical and Civil engineering majors, but did not differ from the Electrical, Chemical, or Biomedical majors. This finding cannot be explored using *The College Majors Finder* (Rosen, Helmberg, Holland, 1989) because the Conventional personality type is not listed as a part of any of the six engineering fields' personality profiles. However, it is interesting that there are significant differences with this personality type instead of one of the other types represented in the personality profiles of the six engineering fields. Other results from this study indicated that women and co-op participants tended to score higher on the Conventional personality type. Perhaps it is time to re-examine and update the personality profiles that are noted in the 1989 edition of *The College Majors Finder* (Rosen, Helmberg, & Holland, 1989). Changes in personality profiles may be occurring in the field of engineering.

The mean scores on the values factors did not differ significantly between engineering fields. It would be interesting to continue to investigate this same question using all 21 values with a much larger sample from a number of universities to see if any significant differences would be found.

Additional Analyses

Additional analyses were performed to explore research question three in a different way. These analyses looked within each field to investigate the differences between the six personality types and the five values factors. For the Electrical engineering major, the Realistic personality type had a higher mean score than Artistic but did not differ from the other four types and the Investigative type had a higher mean score than Artistic, Social, Enterprising, and Conventional. *The College Majors Finder* (Rosen, Helmberg, & Holland, 1989) lists the personality profile for the Electrical engineering major as RIE, however The Occupations Finder (Holland, 1996) states that the occupational code for an Electrical engineering changes to IRE. This may aid in understanding why there was no significant difference between the scores on the Realistic and Investigative personality types. The students who participated in the present study were shifting from college to the world of work, therefore perhaps their scores on the Realistic and Investigative types did not differ from one another because these students were in transition and so were their personality profiles.

As for the values factors, the Inner-Orientation and Material factors had higher mean scores than Group-Orientation and Physical Activity, and Physical Prowess had a lower mean score than the other four factors: Inner-Orientation, Group-Orientation, Material, and Physical Activity. While the Physical Prowess factor appeared to have the lowest mean score for most all engineering fields, the Inner-Orientation and Material factors scores were unique to the Electrical engineering major. This finding indicates that Electrical engineering majors value autonomy and personal development as well as advancement, economic reward, and economic security which are some of the individual values that make up the Inner-Orientation and Material factors.

For the Civil engineering major, mean scores were lower for the Artistic personality type than for the Realistic, Investigative, Social or Enterprising types and the Conventional type had a lower mean score than the Investigative and Enterprising types. None of the types with higher mean scores varied significantly from each other. It is interesting that the only distinction for this field of engineering rests with the personality types that had the lowest scores. When assessing the values factors, the Inner-Orientation factor was higher than Group-Orientation and Physical Prowess was lower than Inner-Orientation, Material, and Physical Activity. These findings are echoed among the findings for other engineering fields.

The Chemical engineering major had a higher mean score on the Investigative personality type than Social, Enterprising, and Conventional and a lower mean score on the Artistic type than all other personality types: Realistic, Investigative, Social, Enterprising, and Conventional. For this field of engineering, the Artistic personality type had the lowest mean score, while the Investigative type had the highest mean score. However it is interesting that the Investigative type did not differ significantly from the Realistic personality type. According to *The College Majors Finder* (Rosen, Helmberg, & Holland, 1989), the personality profile for the Chemical engineering major is IRS. However, The Occupations Finder (Holland, 1996) indicates that the personality profile for a Chemical engineer is IRE. Because there was no significant difference between the Realistic and Investigative types, this may indicate that the two types could be interchanged, for instance, the personality profile for the Chemical engineering major could be IRS or RIS. Perhaps this is more evidence that practitioners need to focus on the scores associated with personality types not just the positioning assigned to types within profiles.

When assessing the values factors, the Physical Prowess values factor had a lower mean score than the other four factors: Inner-Orientation, Group-Orientation, Material, and Physical Activity, while Physical Activity had a lower mean score than Inner-Orientation, Group-Orientation, and Material. These findings show the low importance that Chemical engineering students assign to working physically.

The Industrial engineering major had a lower mean score on the Artistic personality type than the Investigative, Enterprising, and Conventional types. Again the Artistic type had the lowest mean score and differed significantly from the three types with the highest mean scores. An analysis of the values factors indicated that the Inner-Orientation values factor had a higher mean score than the Physical Activity factor and that the Physical Prowess factor had a lower mean score than the Inner-Orientation, Group-Orientation, Material, and Physical Activity values factors. While the Inner-Orientation factor did not differ significantly from the other two factors with high mean scores, it did differ significantly from the two lowest mean scores, Physical Activity and Physical Prowess.

There were no significant differences between personality types within the Biomedical engineering major. With regard to the values factors, Inner-Orientation had a higher mean score than the Physical Activity factor and the Physical Prowess factor had a lower mean score than the Inner-Orientation, Group-Orientation, Material, and Physical Activity values factors. This finding mimics the results found for the Industrial engineering major regarding the values factors.

For the Mechanical engineering major, the Realistic personality type had a higher mean score than the Social, Enterprising, and Conventional types, the Enterprising personality type had a higher mean score than the Conventional type, and the Investigative personality type had a higher mean score than the Social and Conventional types. These findings indicate that while the Realistic and Investigative personality types did not differ from one another, they were the types with the highest mean scores for this field of engineering. *The College Majors Finder* (Rosen, Helmberg, & Holland, 1989) and The Occupations Finder (Holland, 1996) report the personality profile of the Mechanical engineering major and the working Mechanical engineer as RIS. Therefore, the finding that the Enterprising and Social personality types as well as the Enterprising and Investigative types did not differ with regard to mean scores for this field is interesting. Perhaps the people aspect of this field of engineering represented by the Social type in the profile, is becoming better represented by the Enterprising personality type rather than by the Social type. The Artistic personality type also had a lower mean score than the Realistic, Investigative, and Enterprising types. This finding is similar to the findings of other engineering fields.

As for the values factors, the Inner-Orientation factor had a higher mean score than the Group-Orientation and Physical Activity factors and the Physical Prowess values factor had a lower mean score than the Inner-Orientation, Group-Orientation, Material, and Physical Activity factors. While the Physical Prowess finding is similar to the findings for other engineering fields, it is interesting that a field with a profile of RIS valued autonomy and achievement more than social interaction or social relations in the present study. Apparently the values associated with the Social personality type do not outweigh the values associated with the Realistic or Investigative types for this field. Perhaps this finding also confirms the possible replacement of the Social type in the third position of the personality profile for the Mechanical engineering major with the Enterprising type.

## Possible Practical Uses of Results

There are several possible practical uses of the results from the present study that could assist career counselors and academic advisors working with students who are either undecided or are thinking about exploring some type of engineering field.

It is important to realize that experiences can change interests and values. Research has indicated that males and females have different experiences in schools of engineering (Takahira, Goodings, & Byrnes, 1998; Tonso, 1996). This finding was seen in the present study as well. While males tended to score higher on the Realistic or Investigative personality types, females tended to score higher on the Conventional personality type. Thus, advisors and counselors should keep an open mind to those females who do not score as high on the traditional engineering personality types of Realistic and Investigative like their male counterparts and perhaps even encourage those females who show an interest in the Conventional type to explore different fields of engineering.

It might also be important for academic advisors and career counselors to know that in the present study, exposure to a Cooperative Education program was related to higher scores on the Conventional personality type rather than higher scores on the Realistic type as compared to those students who did not participate in a co-op experience. It is also interesting to note that the results related to participating in a co-op program were different from the results related to participation in engineering work experience. This finding supports the research that makes note of the differences between a structured co-op experience and engineering work that is part time or only over the holidays or during the summer. Other studies (Lozano-Nieto, 1998; Whitaker, 1998; Hackett, Martin, & Rosselli, 1998; Bayless, 1999; and Riess, 1999) have discussed the benefits of participating in a co-op program and these advantages may be important to discuss with students who have a choice in participating in a co-op program or engineering work experience.

During an advising or counseling session, focus is often on the positioning of each of the six personality types within a personality profile when interpreting assessments such as the Self-Directed Search and the Strong Interest Inventory. However, the findings related to research question three in the present student would encourage academic advisors and career counselors to give attention to the differences between actual scores on the personality types that make up a personality profile when working with individual engineering students. From the SDS Professional Manual, the "rule of 8" states that if the scores associated with each personality type are within 8 of each other then their positioning can be switched (Holland, 1985). This rule seems especially important for this engineering sample because of the relationships between the six different personality types for each of the engineering fields.

Finally, it may be important for advisors and counselors to use more than just interest inventories when helping engineering students choose an engineering field they wish to study. While there were significant differences among the fields on the scores for the values factors, predominantly the Physical Prowess factor had the lowest mean score and the Inner-Orientation factor had the highest mean score. This finding points to the possible need to use values assessments and/or other assessments to aid engineering students in their career decision-making process.

## Limitations of Results and Future Research

There are several possible limitations to the results found in the present study which lead to opportunities for future research. As mentioned earlier, this study did not focus on why the differences exist between the fields of engineering or what the possible causes of the differences might be. While this area of study is important and encouraged, the nature of the present study was to simply find what differences do exist.

An area of research that the present study was unable to explore was to investigate the relationship between personality types and values among engineering students and engineers in the world of work and well as other specific occupational fields. While there is ample research on broad occupations, there appears to be much to learn within specific career fields.

While a number of significant differences and helpful results where obtained in the present study, it might be beneficial to pursue the same research questions within a longitudinal study and with a larger sample using a number of universities with colleges of engineering that would extend the present study beyond the students at The University of Tennessee. This would enable the results to be more generalizable for college students and enable more analyses, such as exploring all 21 values instead of using the values factors or explore the effects of other experiences not noted in the present study on engineering students. It is also important to remember that this study is being conducted with college students and may not be generalizable to engineers in the world of work.

When exploring the possible reasons that women scored higher on the Conventional personality type, one must also consider that other experiences could be influencing the gender differences found on the Realistic, Investigative, and Conventional personality types. Having more women's experiences to draw upon would be helpful in future research.

The results related to students' having co-op experiences may need further exploration. At The University of Tennessee, students chose to participate in a co-op program. Thus, the findings in the present study may be reflecting the differences that existed in the students before their co-op experience, instead of being a result of the experience. The present study is unable to further investigate this possibility. However, future research could involve universities that require their engineering students to participate in a co-op program to see if similar results are found.

While no significant findings related to participation in undergraduate research were found, perhaps a larger sample of undergraduate research participants might find a different outcome. Again, with a larger sample and other universities represented, the present study can be validated.

Analyses of personality profiles corresponding to the six engineering fields was not possible in the present study due to the large number of profiles represented by each engineering field. Therefore, the direct examination of Holland's personality profiles, which normally consist of three personality types, for each of the engineering fields examined in the present study was not possible. Even when using the "rule of 8" suggested by Holland, there were too many profiles represented within each engineering field. Holland's "rule of 8" states that if the scores for the individual personality types that make up a personality profile are within 8 of each other then they are within the limits of measurement error and their order in the profile can be switched (Holland, 1985). One would need a larger sample to investigate the personality profiles by field. However, based on the findings related to the Realistic, Investigative, and Conventional personality types found in this study, perhaps it is time to re-examine and update the personality profiles related to specific engineering fields found in *The College Majors Finder* (Rosen, Helmberg, & Holland, 1989). An updated analysis would help to alleviate the confusion between the different personality profiles found in The Occupations Finder (Holland, 1996) for the same six engineering fields that were assessed in the present study.

A final future research suggestion is that it may be time to re-examine and update the personality profiles that are noted in the 1989 edition of *The College Majors Finder* (Rosen, Helmberg, & Holland, 1989). Changes in personality profiles may be occurring in the field of engineering. There may have been significant changes in the work environment due to all of the new informational technology since 1989 which could be effecting who enters engineering. It could be that the personality types endorsed by undergraduate engineering majors in the present study expresses how the current fields of engineering have changed.

## Conclusion

Findings from research question one indicated that, while values and personality types (interests) are related, the two appear to be different constructs in the present study given the way the assessments measure both Holland's six personality types and Super's 21 intrinsic and extrinsic values. Research question two investigated different experiences that engineering students can have which may be related to differences in personality types and values. Gender differences found among three personality types and one values factor was not surprising given previous research. However, it is not known if gender itself is the cause of the differences found in this study, if diverse experiences within engineering caused the differences or if a third unknown factor may have effected the results. Regardless, advisors and counselors should be made aware of the possible gender differences until further studies can clarify this finding. The differences found between those who co-oped and those who did not on two personality types and one values factor indicates a need to investigate possible effects of having a co-op experience. However, in the present study it is not known if the differences existed before the co-op experience or because of it.

Research question three explored fields of engineering with regard to personality types and values factors. Differences found among fields of engineering on three personality types was significant in that a portion of the findings not only differed from

Holland's findings listed in *The College Majors Finder*, but the findings surrounding the Conventional personality type could not be discussed using *The College Majors Finder*. This result may indicate a need to update *The College Majors Finder* or at the very least create a larger study to attempt to replicate these findings. Additional analyses assessed the differences between personality types for each of the fields of engineering. Findings supported the initial results and presented how the personality types differed from each other for each engineering field. Even the results found through the additional analyses conflicted with Holland's work on *The College Majors Finder*. While no significant differences were found among fields of engineering when examining individual values factors, additional analyses found significant differences among values factors when exploring individual fields of engineering. These findings need to be replicated using a larger sample. A larger sample would also allow for exploration of all 21 values on The Values Scale along with the five values factors used in this study.

The present study was aimed at investigating the relationship between personality types or interests and values as well as initiating preliminary research on differences between engineering fields with regard to the personality types and values. It is hoped that these initial findings can offer information to assist career counselors and academic advisors when working with engineering students in their career decision making process. It is also hoped that the findings will encourage further investigations into the roles that personality types and values could play when working with potential engineering students or engineering students trying to choose a specific field to study.

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APPENDICES

APPENDIX A

LETTER TO ENGINEERING PROFESSORS

Amanda L. Price
100 Dunford Hall
Knoxville, TN 37996
865-974-5435
alprice@utk.edu

Dear :

Thank you for allowing me to gather student information for my dissertation in your senior engineering class. As we discussed, I will be coming to your class to administer my questionnaire at your convenience. This letter is meant to give you more information about me, my study, and its intended benefits to the College of Engineering at The University of Tennessee.

I am a third year student in the College of Education earning a Ph.D. in Counseling Psychology. I have had the opportunity to work as a facilitator for both Electrical and Chemical Engineering senior capstone teams and have worked with Dr. Elaine Seat on research surrounding the ENGAGE program. These experiences created my sincere interest in working with engineering students. My career goal is to work in higher education as a faculty member and/or counselor so that I might be able to continue work with engineering students.

My dissertation focuses on the career development of engineering students. By having your students complete the assessment packet that I have put together, I want to explore both interests, measured by the Self-Directed Search, and values, measured by the Values Scale, of students in different engineering majors. I am also interested in the possible differences between students who have participated in co-ops and/or research and those who have not. The hope is that this information will assist advisors and counselors in helping freshmen and sophomore students find their occupational fit and thus continue to major in engineering as well as stay in their particular field after college graduation

If you have any questions about me or my research, please feel free to contact me by phone or email at the number and address listed above.

Thank you again,

Amanda L. Price

# APPENDIX B

## STUDENT INFORMATION/INFORMED CONSENT

STUDENT INFORMATION/CONSENT FORM

Dear Student,

I am a graduate student in the Counseling, Deafness, and Human Services Department at The University of Tennessee. As part of a research project, I am assessing the interests and values of engineering students. This research is being conducted in partial fulfillment of my doctoral requirements. I am requesting your participation in this research.

Your participation will require the completion of an *Information Sheet*, the *Self-Directed Search*, and the *Values Scale*. This assessment packet will take approximately 30 minutes to complete.

All information gathered is strictly confidential and at no time will individuals be identified. Your participation is voluntary and you may choose to withdraw at any time. In order to ensure confidentiality, once you have returned your materials, they will be kept in a locked file cabinet at The University of Tennessee. The results of the research will be made available through automated databases and print formats.

Completing and returning the instruments implies that you are giving your informed consent to act as a participant in this research. If you have any questions please do not hesitate to contact me (865-974-5435) or my advisor, Dr. Marla Peterson, a professor in the College of Education at The University of Tennessee (865-974-5131). Enclosed are two copies of this letter. One is for you to keep and the other is to be returned with your packet.

Thank you.

Sincerely,

Amanda L. Price

# APPENDIX C

# DATA COLLECTION INSTRUMENTS

**INFORMATION SHEET**

Directions: *Please fill in or check the appropriate answer.*

1. Age:______ 2. Gender: Male ☐ Female ☐

3. Race: American Indian/Alaskan Native ☐ Asian/Pacific Islander ☐
Black/African-American ☐ Caucasian ☐ Hispanic ☐
Other ☐ ____________________

4. Marital Status: Single ☐ Married ☐ Divorced ☐ Remarried ☐

5. Hometown (city, state):_________________________________

6. Did you participate in the ENGAGE program? Yes ☐ No ☐

7a. Major:__________________ 7b. Concentration (if applicable)__________________

8. Minor (if applicable):___________________________

9. Why did you choose this major?____________________________________________

________________________________________________________________________

________________________________________________________________________

10a. Do you have a scholarship? Yes ☐ No ☐
10b. If Yes, what is the name of your scholarship?____________________________

10c. What is the total $value you have received during the time you have been enrolled at UT?_____________________________________________________

11 Do you have over 90 credit hours total? Yes ☐ No ☐

12. Have you applied for senior standing? Yes ☐ No ☐

13. When do you plan to graduate? ___________________

14. Current GPA:___________

15a. Have you participated in a co-op program? Yes ☐ No ☐

15b. If YES, for what company did you work? ______________________________

15c. Where were you located? ______________________________________

15d. How many months total have you co-oped? _____________________

15e. If NO, do you plan to co-op before you graduate? Yes ☐ No ☐

16a. Have you ever participated in any engineering type work experience (i.e. summer or holiday work)? Yes ☐ No ☐

16b. If YES, for what company did you work? ______________________________

16c. Where were you located? ______________________________________

16d. How many months total have you had engineering type work experience? _________________________________

17a. Have you participated in research in the College of Engineering? Yes ☐ No ☐

17b. If YES, was it your own original research? Yes ☐ No ☐

OR did you work on research started by a faculty member? Yes ☐ No ☐

17c. If NO, do you plan to participate in research before graduation? Yes ☐ No ☐

18a. Have you ever worked closely with engineering faculty (i.e., labs, projects, courses)? Yes ☐ No ☐

18b. What did you do? _____________________________________________________

_____________________________________________________________________________

_____________________________________________________________________________

## TEST NAMES AND PUBLISHER INFORMATION

The publishers of the instruments used in this study and their contact information, including mailing address, telephone number, and web address are listed below.

Self-Directed Search

Psychological Assessment Resources, Inc.
16204 N. Florida Ave., Lutz, FL 33549
(813)968-3003
http://www.parinc.com/

Values Scale

Consulting Psychologists Press, Inc.
3803 East Bayshore Road, Palo Alto, CA 94303
(800) 624-1765 or (650) 969-8901
http://www.cpp-db.com/

# VITA

Amanda Lynn Price was born in Raleigh, North Carolina on July 19, 1974. She was raised in Wrightsville Beach, North Carolina and attended Cape Fear Academy where she graduated from high school in June 1992. She then began attending Wake Forest University in August of 1992. During her years at Wake Forest she was awarded the William Louis Poteat Scholarship and was initiated into the sorority Delta Delta Delta. In December 1995, she graduated cum laude with a Bachelor of Arts degree in Psychology and a minor in Speech Communication. In August of 1996, she entered The University of Tennessee, Knoxville and received a Master of Arts degree in Psychology in May of 1998. During her Master's degree she worked with Dr. Warren Jones and completed a thesis entitled "The Fulfillment of Social Provisions and its Relationship to Psychological Well-being." In the summer of 1998 she began pursuing a Ph.D. in Counseling Psychology. During her time in the Counseling Psychology program she was initiated into Phi Kappa Phi honor society. Amanda's internship was completed at The University of Georgia's Counseling and Testing Center during the 2001-2002 school year. Her doctoral degree was awarded in August 2002.