PERSONALITIES AND PIPELINES: EXPLORING THE ROLE OF PERSONALITY IN STUDENT SELF-SELECTION INTO STEM MAJORS

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Despite all the national efforts to increase STEM enrollment in the United States, the gap between the U.S. and other developed countries in terms of STEM graduates has widened over the last 20 years. Researchers have studied factors such as gender, race, high school GPA, and the student's socioeconomic status for their impact on STEM enrollment. This study offers another possible explanation of why students might choose, or not choose, to enroll in STEM majors by examining the relationship between personality and STEM enrollment. The sample included 2,745 respondents to the 2008 Cooperative Institutional Research Program freshman survey at a large research university in the southwestern United States. Factor analysis was used to create four personality scales, based on John Holland's theory of personality types, with items selected from the survey. Logistic regression was utilized to answer three research questions: Are students classified as a strong investigative personality type more likely to enroll in STEM majors than students classified as a weak investigative personality type? Are there differences in their likelihood to enroll in STEM majors among students of investigative-social, investigative-artistic, and investigative-enterprising personality types? What effect does personality have on students' self-selection into a biological versus a physical STEM major? Results suggested that students with a combined investigative and social personality were more likely to enroll in STEM majors whereas students with a combined investigative and artistic personality were less likely to do so. Additionally,

STEM students with an enterprising personality were more likely to choose a biological STEM major than a physical STEM major. These results should benefit educators and policy makers who seek to strengthen the pipeline into STEM fields.

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CHAPTER I

INTRODUCTION

Context of the Problem

Concern over the diminishing competitive edge of the United States in science, technology, engineering, and mathematics (STEM) is escalating. Despite the fact that the United States is fully entrenched in a global marketplace dependent on innovation and advancement in STEM, its ability to continue as a leader in these fields is being called into question. The loss of leadership in STEM for the United States can be traced to lack of early preparation of students for entering STEM majors, college enrollment and graduation patterns in STEM majors, and overall stagnation in total STEM enrollment.

Although statistics from the National Science Foundation (NSF, 2003) show a 15% increase for all STEM baccalaureates from 1985-2000, with interest in biological science majors in particular skyrocketing (Astin, Oseguera, Sax, & Korn, 2002), if degrees in the biological sciences are removed from the data, those statistics show an approximately 19% overall decline in STEM enrollments. In addition, compared to other developed countries, the number of students in the United States graduating with STEM majors is dismal. Both Asian and European Union countries graduate about one quarter to two thirds of their students in STEM, whereas the United States has a mere 15% of undergraduates receiving STEM degrees (National Academies, 2007). Of additional concern is the relatively poor showing of the student pipeline into STEM majors. That is, preparation of middle and high school students in math and science courses has fallen well behind efforts made in other developed countries.

International education achievement surveys support the discouraging news regarding the lack of educational preparation in high school math and science coursework. In 2006, 15-year-olds in the United States scored lower, on average, in mathematics than did their peers in 18 of the 24 compared countries (Burrelli & Rapoport, 2009). In a six-year period ending in 2006, high school students in an additional six countries scored higher in science scores over their peers in the United States—doubling the number of countries exceeding assessment scores for the United States (Burrelli & Rapoport, 2009).

These statistics showcase the tremendous depletion of available talent in engineering, mathematics and the physical sciences in the United States. Additionally, given that approximately 90% of high school seniors indicate a desire to attend college (Hurtado, Inkeles, Briggs, & Rhee, 1977), the lack of preparation for potential STEM majors compounds the decrease in global competitiveness.

In response to the growing alarm over the United States' declining competitiveness in producing workers prepared for the needs of the 21st century, multiple programs have been implemented seeking to increase enrollment and persistence in STEM majors. According to the National Science and Technology Council Committee on Science (NSTC, 2006), funding allocations for STEM education and learning by the federal government was about $190 million in 2003. Labov, Singer, George, Schweingruber, and Hilton (2009) stated that "billions of dollars on more than 200 programs" (p.157) has been spent since the beginning of this decade in an attempt to improve STEM pipeline education and undergraduate STEM education. These numbers do not take into account the millions of dollars spent by private organizations seeking to revamp STEM enrollment and persistence.

A number of private foundations and corporations seek to promote greater involvement in STEM. Among the most well known are programs such as Developing Futures in Education ($125 million, GE), the National Math and Science Initiative ($125 million, Exxon) and Project Lead the Way ($1. 5 million, 3M; $2 million, Cargill; $1. 125 million Chevron). These programs were developed by industry giants as a means to ameliorate the crisis in STEM education as well as to address concern over the lack of a workforce prepared to meet the needs of a global society (Reppert, 2008). Hewlett Packard (HP) recently announced a $6 million commitment to STEM education with the establishment of the HP Catalyst Initiative, led by the Sloan Consortium (Pacheco, 2010). Additionally, the Bill and Melinda Gates Foundation (2011) is well known for the millions of dollars spent by that foundation on educational research.

Although there is evidence that these current programs for STEM recruitment are somewhat successful, there is concern over the lack of coordinated effort and oversight of the programs. Subotnik, Edmiston and Rayhack (2007) reviewed various federal, state and private programs designed to enhance STEM education for high school students and noted several barriers to progress in formulating best practices for STEM education. Among the barriers noted were how STEM talent is defined, what specific outcomes for programs should be, lack of longitudinal studies on program outcomes, unequal STEM access, poor teacher qualifications and the lackluster social position of STEM careers.

Of particular interest to me is a finding by Subotnik, Edmiston, and Rayhack

(2007) that only 17 of 56 specialized STEM schools, with available admission criteria, required applicants to have an actual interest in science and mathematics. The majority were concerned primarily with academic achievement alone based on standardized testing that includes verbal as well as mathematical ability. Moreover, none of the standardized testing included consideration of spatial ability, which according to the National Science Board (NSB)(2010) is a key element in STEM ability--either alone or in combination with other more commonly tested abilities. It is arguable that interest in science and mathematics, and spatial ability, should merit consideration when determining which students might benefit from educational experiences in STEM. Also noteworthy is the recommendation of Subotnik, Edmiston, and Rayhack (2007) to offer “open enrollment” into special STEM schools to determine whether students who have an interest in STEM subjects, but without the standardized test scores, can succeed as well as students admitted based on test scores.

It is clear from the works cited in the preceding paragraphs that current expenditures on STEM education are having only minimal impact on resolving the problem the United States faces with decreasing interest in pursuing STEM careers. New approaches are needed to explore options outside of the present cadre of teaching/learning paradigms being researched.

Purpose of Study

The purpose of this study is to investigate the impact of personality on a college student’s self-selection into STEM majors. Since the National Science Board (2010) believes that “the interest (or disinterest) in STEM germinates early in K-12, maybe even in early childhood" (p.10), this study may also provide information on how best to assess and cultivate students for STEM careers at earlier ages.

Theoretical Framework

The choice of a college major can be seen, ultimately, as the intent to pursue a particular profession or career. In today's educational marketplace, the purpose of a college degree is no longer simply the acquisition of knowledge for growth and enlightenment, but rather a method by which one gains financial independence and establishes a place in society. In fact, according to the 2011 Pew Research Center report "Is College Worth It?" 55% of graduates felt their college degree readied them for the job marketplace, and 86% felt that money spent on college was a "good investment" in their future.

For this reason, the theoretical framework used for this study is John Holland's (1997) theory of vocational personalities and work environment. Although this theory is not specific to an individual's personality, the overall intent of the theory is to explain how congruence between an individual's personality and a profession's personality can affect the overall satisfaction, and retention, in that profession. Since the premise of this study is that a student's personality plays a significant role in selection of a college major, it was an intuitive leap to accept that congruence between a student's personality and college major choice would also result in overall satisfaction in that major.

Holland's Theory of Vocational Personalities and Work Environment

There are four basic assumptions upon which the Holland theory is built. The first two assumptions are that both individuals and environments can be characterized by one of six personality types (realistic, investigative, artistic, social, enterprising and conventional). The last two assumptions are that behavior is a function of environmental/individual interaction and that individuals look for environments that allow the full expression of their personality in terms of skills, attitudes and values (Holland, 1997).

Spring-boarding from the four assumptions are some foundational principles Holland used to develop his theory. Essentially, Holland states that people choose a vocation because it matches their personality and that members of a particular vocation will, because of similarities in personalities, respond to events in much the same way (Holland, 1997). Holland also states that “vocational satisfaction, stability and achievement depend on the congruence between one’s personality and the environment in which one works” and that “interest inventories are personality inventories” (pp. 8 and 11).

Studies regarding the use of interest, or personality inventories, as a method for determining one’s ultimate career and by extrapolation, STEM major, are not new to industrial or occupational researchers. Among the most well known instruments used to assess personality are the Myers-Briggs Type Indicator (MBTI) and the Strong Interest Inventory (SII) (Balgopal, McLean & Kaufman, 1994). Although the MBTI has perhaps more popular appeal, the SII has been more prominent in the research on person-environment fit, including research on student choice of major, which could be considered a proxy for the ultimate environment for which a student would be prepared.

The SII was developed from Holland’s theory based on his belief that “vocational interests are expressions of people’s personalities” (Nauta, 2010, p.12). The concept behind the SII is that knowing the interests of an individual helps develop a profile of that individual which allows for characterization of that individual into a specific personality type, which would then be matched to a congruent vocational personality type.

A discussion of the psychosocial theories used by Holland to develop his personality types is presented in chapter II. However, the essence of Holland's typology stems from the belief that genetic-environmental interaction creates in individuals the propensity for enjoyment of certain activities over others. These activities become more solidified as interests, and the continued pursuit of these interests, leads to development of specific behavioral patterns and attitudes that can be used to characterize personality types (Holland, 1997).

Holland's theory is illustrated utilizing a hexagonal model with the six personality types arranged in a specific order around the hexagon. Those personality types next to one another on the hexagon are the most alike, while those at the greatest distance are the least similar. Using an individual's score from an interest survey such as the SII, one would be able to determine not only what the dominant aspect of an individual's personality is, based on placement on the hexagon, but also what vocational environment type might best match that individual. These scores also help delineate a strong personality type over a weaker personality type. In other words, the higher the score achieved for a particular personality type, the stronger that personality type manifests in the individual.

Research Questions

In this study, I utilized responses to the Cooperative Institutional Research Program (CIRP) freshman survey to determine the impact specific personality types might have on self-selection into a STEM major. The following research questions guided this study:

1. Are students classified as a strong investigative personality type more likely to enroll in STEM majors than students classified as a weak investigative personality-type?
2. Are there differences in their likelihood to enroll in STEM majors among students of investigative-social, investigative-artistic, and investigative-enterprising personality types?
3. What effect does personality have on students' self-selection into a biological versus a physical STEM major?

Definitions

The following terms are operationally defined for the purpose of this study:

- Personality is operationally defined as John Holland's (1997) six personality types: realistic, investigative, artistic, social, enterprising and conventional.
- Designation as a strong investigative personality denotes a *z*- score of equal to or greater than a +1 on the scale developed from CIRP survey items.
- Designation as a weak investigative personality denotes a *z*- score equal to or less than a -1 on the scale developed from CIRP survey items.
- STEM majors include science, technology, engineering and mathematics majors defined by the Classification of Instructional Programs (CIP; NCES 2002).
- College major is defined as the program of study selected by students on the CIRP freshman survey.

Significance

This results of this study provide information regarding moderators that affect student's choice of college major, which will aid in counseling students towards a major congruent with not only their ability, but interest and personality. Information from this study help inform policymakers and educators on how best to identify students in K-12 grades that have interest in and potential for STEM careers, thus creating a consistent pipeline into areas having enormous impact on the future competitiveness of the United States. Studies have already shown a need for better "best practices" regarding STEM education (Labov et al., 2009). This study helps both students and educators make better choices regarding education, and perhaps helps eliminate the dismal retention rates seen in so many institutions of higher education.

Furthermore, research has shown that gender and race/ethnicity have great impact on college student success and choice of major. The results of this study advance the understanding of how gender or race/ethnicity interact with personality to affect a student's decision to enroll in a STEM major, and provides information on strategies to be used at various levels of the educational process to ensure that these moderators do not adversely impact STEM enrollment.

From a policymaking point of view, increasing STEM enrollment has been the driving force behind much of the public and private funding in education. As discussed earlier in this chapter, the success of the various programs in increasing that enrollment is at best mediocre (Labov et al., 2009). So much of what is done today in STEM readiness education is based solely on perceived aptitude in a given area, rather than other moderators that may affect overall ability (Subotnik, Edmiston & Rayhack, 2007).

Results from this study may help inform policymakers of alternative methods for funding programs designed to increase interest, enrollment and retention in the STEM fields. If it can be shown that personality plays a role, and perhaps a dominant one, in students' choice of college major, then funding efforts might focus on better determination of personality at a younger age, where programs designed to create interest can often be more effective.

Organization of the Study

This study is organized into five chapters. Chapter I includes a review of both the educational and financial aspects of the problem, the purpose of the study, the theoretical framework of the study, the research questions, definitions of terms and the significance of the study. Chapter II includes a review of the literature covering the current state of STEM education, labor force issues in STEM, student retention in STEM, research on STEM majors, research on personality, and research on Holland's theory and major choice Chapter III explicates the methodology used in the study with information on the secondary database used, size and selection of the sample, variables, development of personality subsets, and data analysis procedures. Chapter IV presents the results of the analysis while Chapter V offers a discussion of the results, limitations to the study, the implications produced with the results, and suggestions for further research.

CHAPTER II

LITERATURE REVIEW

Status of STEM Education in the United States

Although the figure varies somewhat based on the definition of STEM (science, technology, engineering, mathematics) enrollment or timing of that enrollment, the overall current picture of STEM enrollment for freshmen students in the United States is about 22% (National Center for Education Statistics, 2009). However, as noted in chapter I, concern about stagnant enrollment patterns in STEM pales next to concern over poor retention rates of students in these majors. Whereas Tan (2002) noted that a little more than 60% of STEM majors graduated in STEM, today the figures show a much more dismal graduation rate, particularly for racial and ethnic minorities. For example, STEM data from the Higher Education Research Institute at UCLA (as reported by Commission on Professionals in Science and Technology, March 2010) shows that for students beginning college in a STEM major, fully 66% of Whites and 58% of Asians do not graduate with that major. This low completion rate is repeated for other ethnic groups with Blacks graduating only 18% of those originally enrolled in STEM, Latinos 22%, and Native Americans 20%.

Low retention rates in STEM majors do not give a complete picture of the current situation in STEM enrollment however. Gaps in the percentage of racial and ethnic minorities enrolled in STEM compared to Whites, as well as continuing gender differences among students enrolled, showcase the complexity of the problem.

Although the gaps between gender and ethnic groups in STEM enrollment appear to be closing, with more underrepresented minorities and females initiating

STEM degrees, overall the percentage of students enrolled in STEM remains static (National Science Foundation, 2003). The crux of the problem is that while the proportion of minority students enrolled in STEM majors has increased over the past twenty years, with Hispanics and Asians showing the largest increases (2 to 9% and 4 to 12% respectively), enrollment for Whites has decreased from 84 to 72%(NSF, 2003). In other words, while equity programs for STEM education have shown some success in increasing minority enrollment in these majors, the decrease in enrollment of Whites in STEM means that the actual overall percentage of students enrolling in STEM has not increased proportional to the need.

Differences in the racial mix of STEM enrollment do show some improvement for underrepresented minorities. However, the gap between genders remains about the same. Men still dominate STEM majors, particularly the engineering, computer science and mathematics fields with 33% of all college male students enrolling in STEM compared to 14% of female students (Chen & Weko, 2009).

One additional concern about the continued enrollment disparities is that by 1997 about 70% of STEM employees were white males, while underrepresented minorities, not including women, only encompassed about 6% (George, Neale, Van Horne & Malcom, 2001). Given that the population of white males in the United States is expected to decrease by 10% by 2050, while non-white minorities will increase to about 50% of the population (U.S. Census data, 2011) during this same timeframe, it is imperative that better methods for increasing and retaining underrepresented talent in the STEM field be utilized.

Research on the Successful STEM Programs

Over the years, researchers on STEM education have reached a consensus that high school preparation is the leading cause for low STEM enrollment and retention rates (Campbell, Hoey, & Perlman, 2002). Evidence from a meta-analysis of both private and public programs developed for enhancement of high school STEM preparation showed many issues with the current modalities used to encourage pursuit of STEM professions (Subotnik, Edmiston & Rayhack, 2007). In most instances, the various methods utilized in attempts at increasing STEM interest have been isolated and have differing goals. Thus it has been difficult to determine what method, or methods, has the most success in stoking the STEM pipeline (Labov et al., 2009).

Most research has shown that the most efficacious methods for ensuring entry of students into STEM majors are exposing students to research and increasing students' mastery of math and science subjects while in high school. Both approaches were found to be powerful factors also in determining completion in STEM majors (Campbell et. al. 2002; Crisp, Nora & Taggart, 2009, Shernoff & Hoogstra, 2001; Tan, 2002). However, concerns regarding teacher qualifications, specific outcomes of programs and unequal access to research-like experiences hamper these approaches. Additionally, consideration must be given to what individual factors are present that might account for a student's interest in a STEM major. For instance, in a study on specialized high schools for STEM, Subotnik, Tai, Rickoff and Almarode (2010) discussed student decision making regarding STEM commitment as being partly determined by how well the attributes of a given STEM major fits with the student's own self-image. In other words, according to these authors, students choose particular fields because of an "image match" between themselves and that field.

However, these factors alone have not been able to adequately explain why students enroll in STEM majors or what causes students to subsequently leave those majors. While it has been shown that mastery of a given subject, and enjoyment of that subject can lead to increased persistence in the subject (Shernoff & Hoogstra, 2001) and that student engagement can also impact that students' decision to enroll, or remain in, STEM subjects, national statistics continue to show that STEM enrollment remains static in the United States. Even with the gains seen in female and minority enrollment, the discrepancies are still great, leading to a continued overall depletion of STEM talent in the United States (Tan, 2002).

Despite past and current efforts by both private industry and governmental programs little progress is being made in increasing, or even maintaining, enrollment in STEM majors (Labov et al., 2009; NSF, 2010; NSTC, 2006; Reppert, 2008). The National Science and Technology Council Committee on Science (NSTC) (2006) formed a subcommittee on education and workforce for the specific purpose of "analyzing…. the federal government's investment in learning and education within the domain of science, technology, engineering and mathematics" (p. 2). Some of the findings from the subcommittee include the following: a) more than half the programs involve equity issues in STEM education, b) current research does not really address the current issues, and c) current research is unsubstantial or inconsistent in results. In other words, greater than 50% of the focus in STEM education currently is on identifying and eliminating barriers to STEM enrollment experienced by underrepresented minorities and females with a success rate in this area disproportionate to the costs involved (Labov et al., 2009; NSF, 2003).

In addition to the narrow focus of current research on STEM, one might also conjecture that past research has focused too much on the extrinsic forces--such as socioeconomic status, type of high school, gender or race creating barriers for various groups of students—without an equal focus on intrinsic factors—such as motivation, interest, or personality that impact decisions made about college. Key recommendations from the NSTC subcommittee include the need for further research on career patterns and student learning, as well as connecting the research with policymaking and practice (NTSC, 2006). Researchers on STEM education need to do a better job of identifying why certain careers are chosen, how students learn, and the best practices for increasing that learning, in addition to providing research beneficial to those educating these students and enacting policy that mandates the direction of education.

Coupled with the need for future research on current programs designed to increase STEM enrollment and participation, there is also controversy over whether the most talented students, and those perhaps with the most potential in STEM fields, are being adequately serviced by the educational system. In “Preparing the Next Generation of STEM Innovators: Identifying and Developing our Nation’s Human Capital, 2010,” members of the National Science Board (NSB)(2010) argued that more funding should go towards early recognition and mentoring of high ability students to ensure an increased and consistent pipeline into STEM. In the face of the millions of dollars spent on STEM education, current understanding of various approaches to solving problems in STEM education, or gaining insight into viable educational strategies for STEM, remains limited (Labov et al., 2009). Recommendations made by Labov et al. (2009) based on workshops organized to explore current issues in STEM education, include, among other things, the need to create in students an understanding of the ability of STEM disciplines to help resolve a number of societal issues. This recommendation suggests that emphasizing the value of STEM majors in alleviating environmental or economic issues, for instance, may tap into a student's sense of community, and depending on personality type, may foster a desire to impact those issues.

Labor Market Trends in STEM

In addition to the problem of degree completion rate in STEM majors, labor market trends emphasize growth occupations requiring a strong foundation in math and science, thus intensifying the concern among educators over decreasing STEM enrollment and graduation (Alfred, Shults, Jaquette, & Strickland, 2009). Current information on economic growth in the United States indicates the potential need for 2. 5 million new employees in STEM fields by 2014, which represents a 70% faster growth rate than other occupations (Grossman, 2010). In 2005, the Bureau of Labor Statistics predicted that by 2010 job growth in the United States in STEM fields would increase by 47% over previous decades (Russell, 2005) yet overall graduation patterns in college and universities across the country for the specific types of STEM degrees relevant in today's marketplace continue to decline (Russell, 2005).

The need for workers in STEM occupations is mirrored by the need for increased numbers of researchers in these fields. A leading indicator of commitment to science and technology—investment in research—shows a slowing in the growth of the number of researchers in the United States compared to other countries (National Science Foundation, 2003). In order to prepare future workers for success in a competitive global marketplace, higher education institutions in the United States must find ways to stoke the pipeline into STEM by encouraging students at an earlier age to consider a college degree in a STEM discipline (Tan, 2002).

Choice of College Majors

Attempts to encourage students to look more favorably on STEM fields have resulted in limited success as researchers seek to determine reasons students choose one particular major over another. Many studies have documented the role that race, gender, parental education, type of high school and socioeconomic status play in decisions students make regarding choice of major (Briggs, 2006; Campbell, Jolly, Hoey, & Perlman, 2002; Tyson, Lee, Borman & Hanson, 2007; Pike, 2006; Porter & Umbach, 2006; Subotnik, Tai, Rickoff, & Almarode, 2010). The results of these studies point towards multiple, interconnected variables that can ultimately impact the student's decision to enroll in a particular major. And yet, none of these variables can really explain the underlying reason for a decision made by the student to enter one major over another. Indeed, although many studies have shown that parental education level, for instance, has a significant impact on whether a student enters a science or mathematics major, that factor alone does not account for much of who do and do not choose those majors. It is usually is a combination of factors that affect a student's decision to major in a particular discipline. The problem is that each factor has a different impact on each individual. For instance, while gender is seen as a significant factor among minorities in predicting choice of major (Crisp, Nora & Taggart, 2009), other studies indicated that GPA in high school along with perceived academic ability or choice of course are the significant factors to be considered when determining major choice. Of particular interest to my research are studies showing that a more significant predictor of enrollment in, and persistence with, a science or math major specifically, is the motivation created by interest and enjoyment in the subject (Grandy, 1998; Shernoff & Hoogstra, 2001).

Results from the Shernoff and Hoogstra (2001) study on student engagement suggested that identifying and nurturing innate interest in science and mathematics early in the educational process could help ameliorate the loss of students from these courses in college. What is intriguing about this study is the emphasis placed on the interconnectedness of interest and enjoyment with persistence through high school to college in STEM coursework. Although the findings were more compelling for science than for mathematics, the results clearly showed that "interest and enjoyment in high school math and science classes are significant predictors of academic performance in college" (p. 81). Given what is known about the impact of academic performance in college, particularly as determined by GPA, in predicting successful completion of the college major (Allen & Robbins, 2008) these findings warrant additional investigation.

Consistent with the findings from the Shernoff and Hoogstra (2001) study that highlights the importance of interest and enjoyment is the work of Allen and Robbins (2008) showing that lack of motivation, as well as a poor fit for actual career interests, has a detrimental effect on completing a college degree. Of note, although this study did not support the author's hypothesis that interest-major congruence would positively impact first year performance, the study results did suggest that interest-major congruence was an important variable for completion of college degree. Conversely, student motivation was found to be a determinant of first year performance leading to greater likelihood of degree completion.

While neither study cited suggested that interest, enjoyment or motivation alone are significant predictors of student entrance into, and persistence in a college major, they do offer additional insight into the complex nature of students' choice for major. Adding to that insight is a study by Christie, Munro and Fisher (2004) on determinants of early college departure in students. These authors found that support networks are an important consideration for student retention, as well as choice of coursework and overall sense of belonging to the institution itself. Interestingly, results of this study did not show that racial or socioeconomic variables impacted student departure, but rather an overall sense that the student had simply chosen the wrong course, or even college. This suggests that intrinsic factors affecting student choice may have important implications in student selection of and retention in, college majors.

The body of research appears to suggest that persistence in a college major may be based, in large part, on how well that major matches the personality and values of the student. Research also suggests that factors involving student decision-making in major choice need to include both extrinsic factors such as race, gender, and SES, as well as intrinsic factors such as motivation, interest and personality.

Specific to the research proposed in this paper are studies that have sought to determine what specific factors motivate students to enroll in STEM majors over other majors (Briggs, 2006; Campbell, Jolly, Hoey, & Perlman, 2002; Tyson, Lee, Borman & Hanson, 2007; Subotnik, Tai, Rickoff, & Almarode, 2010). Most have centered on questions regarding the impact of race, gender, socioeconomic status, institutional reputation and type of high school/high school coursework or parental influence. However, results from these studies are inconclusive. While some found evidence of parental influence, others did not (Porter & Umbach, 2006; Simpson, 2001). Some studies concluded that high school coursework plays a prominent role in selection of college major, other refuted this finding (Crisp, Nora & Taggart, 2009; Porter & Umbach, 2006). Much of the research focused on external moderators that have the potential to affect a student's choice of college major. None of the studies looked at the role played by the individual. This study sought to remedy that gap by focusing on the individual and the individual's personality as a determining factor in selection of college major. This is not to suggest that other factors studied previously have no bearing on major selection, but rather that there is a need to explore internal as well as external factors when attempting to determine how and why students choose and persist in a given major choice.

Some studies looking at determining factors for STEM enrollment have studied the impact of personality-environment on student choice of major (Pike, 2006; Porter & Umbach, 2006; Balgopal, McLean & Kaufman, 1994). Most of these studies used Holland's theory to explore the impact of a personality-college major congruency on college expectations and/or achievement, using either the Cooperative Institutional Research Program (CIRP) survey data or data extracted from the interest survey portion of the ACT. Although these studies produced some interesting results regarding the effect of personality-major choice on academic achievement and student stability and satisfaction with the college experience, they used a very limited definition of personality (a student was either investigative or artistic or enterprising, for instance) based on a narrow characterization of that personality from the CIRP survey (using at most six questions taken mostly from two survey categories).

Student Retention in STEM Disciplines

Research on student attrition from college offers many possible explanations for lack of retention ranging from finances and lack of academic preparation, to unwelcoming campuses and student expectation (Daempfle, 2002; Oseguera & Rhee, 2009; Simpson, 2001). There does not appear to be any appreciable difference in findings regarding attrition based on the specific major chosen by the student, so much of the research is easily applicable to STEM majors. In fact, research in the area of retention in STEM majors appears to have the same limitations as other research on college students—much of it is inconclusive, or even contradictory. For instance, Tan (2002) suggested in his study that neither student diversity, nor small class size were significant factors for STEM retention, while Eagan, Hurtado and Chang (2010) suggested that race was a negative factor in retaining STEM students. On the other hand, Chang, Sharkness, Hewman and Hurtado (2010) found that controlling for certain college experiences negated the effect of race on STEM retention. They found that participation in research activities while enrolled in STEM majors had the bigger impact on retention in these majors, a result that echoes findings on the role of exposure to research for STEM major choice (Campbell, et. al2002; Crisp, Nora & Taggart, 2009, Shernoff & Hoogstra, 2001; Tan, 2002).

In addition to these studies on variables affecting retention, studies on females and minorities in higher education documented many barriers facing these groups, and the extent to which those barriers may be factors in attrition among female and minority groups (Cole & Espinoza, 2008; George, Neale, Horne & Malcom, 2001; Tyson et al., 2007). Perceived discriminatory practices, lack of mentors/professors/students of similar backgrounds or ethnicities and underlying and unspoken bias against specific groups lead the list of potential barriers. One interesting finding was that females in general, once started in a STEM major, tend to do better in terms of grades and degree completion rates than do males (Cole & Espiranza, 2008). There was, however, no differentiation of type of STEM major provided in the literature.

Despite evidence that many barriers do exist for specific groups of students interested in STEM, or any other majors for that matter, it appears that findings from these studies can really only account for about 35% of the variances in student attrition across types of institutions (Watson, Johnson, & Austin, 2004). What seems clear from the research is that there may be alternative explanations for student choice—both in college major and determination to stay the course in that major. Data show a narrowing gap between Whites and racial and ethnic minorities, as well as between males and females, in interest in, and achievement of, STEM majors. This indicates that some students from these underrepresented groups manage to overcome various barriers and persist in their goal of completing a college education with a STEM major. The question that needs to be answered is “what intrinsic factor is present in these individuals that might account for the ability to persist with a college education despite the barriers?"

Although the primary focus of this study is on the relationship between personality and STEM enrollment, I believe that personality also has influence on student retention and success. Wilcoxson and Wynder (2010) found that students choosing a major well matched to their ultimate career goals are much more likely to persist through completion than those having less direction to their choice. The decision-making involved in choosing a college major speaks to the idea of goal commitment discussed by Tinto (1975), and is a manifestation of one's personality. In like vein, Allen and Robbins (2008) stated, "students who choose a major congruent with their skills and interests are more likely to succeed and persist in that major and college" (p. 62). Using the ACT UNIACT interest inventory, which is based on Holland's' typology of personality and vocations, Allen and Robbins showed that having a good match between student personality and the "personality" of the major chosen led to a greater likelihood of persistence in the major.

Although many factors have been studied for their impact on student retention no single element has been found to account for the reasons why a student may or may not choose a STEM major. However, the role of personality as an important factor in choosing a particular major in college has gained prominence in recent research as evidence continues to mount regarding the impact personality can have on choice of, and completion in, a college major (Defruyt & Mervielde, 1996; Feldman & Ethington, 1999; Feldman, Ethington, & Smart, 2001; Pike, 2006; Porter & Umbach, 2006).

Personality and the Choice of College Major

A Brief History of Research on Personality

Interest in personality as a predictive measure has waxed and waned over the past 80 years in the United States. Beginning in the 1920's researchers sought to establish personality as a separate topic within the broader fields of psychology, sociology and education (John, Robins & Pervin, 2008). Most research on personality from the 1920's until recently centered on the concept of traits, a collection of characteristics or behaviors that when combined would indicate a specific type of personality (John, Robins, & Pervin, 2008). Concurrent with much of this research was debate on whether personality was simply human nature manifest in a variety of ways, or individual differences developed through socialization, culture and environment.

Personality research has evolved from lists of characteristics symbolizing types, to the idea of broad, but limited, factors that can be used to characterize people. Current thought in personality research postulates that five factors can account for the differences in personality seen in various populations. These five factors are described as a basic tendency of persons towards neuroticism, extraversion, openness, agreeableness and conscientiousness (John, Robins, & Pervin, 2008). Cultural, social, economic and other life events act upon these tendencies to produce the variance in personality seen.

Newer research on the cultural, ethnic or national influences on personality has produced some conflicting evidence on the applicability of the five-factor model across cultures or nationalities (Avdeyeva & Church, 2005; Church, Katgbak, Miramontes, Del Prado, & Cabrera, 2007; Triandis & Suh, 2002; van Langen & Dekkers, 2005). Part of the difficulty with the research in this area is the different perspectives used by researchers for their studies. Some focused more on the universality of traits regardless of culture while others looked to the social aspect of personality development. What we are left with is a body of research still undecided about the applicability of models such as the five-factor for use across ethnicities.

Additionally, there are questions regarding stability of the predictive results of the five-factor model across age and gender (Donnellan & Lucas, 2008; Schmitt, Realo, Voracek & Allik, 2008). Pulkkinen (1996), for instance, found that personality, as defined by behavior, tended to develop continually through interaction with the social environment rather than remain relatively stable as argued by proponents of the five-factor model.

Translating information found from these studies into usable form to evaluate various aspects of the educational process has become the focus of personality research recently, particularly as concerns regarding the educational preparedness of the United States in a global market increase (Larson, Wu, Bailey, Gasser, Bonitz & Borgen, 2010; Nichols, et al., 2007; NTSC, 2006). As researchers search for better understanding of student decision-making, the inclusion of internal moderators as potential determinants has gained greater significance.

Much of the research on personality and education over the past couple of decades centers on student choice of major (Feldman, Smart & Ethington, 1999; Feldman, Ethington & Smart, 2001; Feldman, Smart, & Ethington, 2004; Pike, 2006; Porter & Umbach, 2006). The why and how of this choice is considered to be a determining factor in student retention and completion of the major chosen. Although much research has been done on race, gender and socioeconomic status as major determinants of major choice, particularly with regards to STEM majors (Briggs, 2006; Campbell, Jolly, Hoey, & Perlman, 2002; Tyson, Lee, Borman & Hanson, 2007; Subotnik, Tai, Rickoff, & Almarode, 2010), studies have also looked at the impact of environment and personality in student major selection. One method utilized by many of these researchers is application of Holland's (1997) theory of vocational personalities and work environment to the interaction between student personality and choice of major.

Holland's Theory of Vocational Personalities and Work Environment

The basic concept behind Holland's theory is that the environment surrounding a career has a personality of sorts, and that continuance in, and enjoyment of, the career depends on a person having a personality that is congruent with the environment (Nauta, 2010). Development of his theory that occupations and personalities have similar characteristics came mostly from Holland's work as a vocational counselor (Holland, 1997). No one source served as background to this theory, however Holland took ideas from multiple early sources that suggested that environments could be classified according to the traits exhibited by the people within those environments (Holland, 1997). The hexagonal model used with the theory serves as a pragmatic means of showcasing both the similarities and differences between personality type, both for individuals and environments.

Holland classified individuals into 6 personality types, which he believed evolved out of exposure to the unique culture in which an individual lived (Holland, 1997). The 6 types delineated include: realistic, investigative, artistic, social, enterprising and conventional (RIASEC). Basing his typology on the belief that the experience of growing up in a specific culture creates a preference for particular activities or interests that ultimately, along with the values implanted during one's lifetime, describes a personality type, Holland labeled the 6 personalities using adjectives he felt were most representative of the type. So for instance, an investigative type is likely to be precise, analytical, curious, and intellectual compared to a social type who is more likely to be cooperative, friendly, understanding, or warm (Holland, 1997). Likewise, the artistic personality leans more towards emotional, expressive, nonconforming, or impulsive attributes as opposed to the enterprising type who would be more adventurous, ambitious, energetic, and self-confident (Holland, 1997). Although his theory was formulated for determining best vocational fit, Holland also used his theory to predict educational behavior. He believed that "the choice of, stability in, and satisfaction with a field of study" (Holland, p. 30) is determined by a person's personality type. Extrapolating from Holland's premise and using his typology method, it is felt that those students with a strong Investigative personality type would be most likely to select a STEM major.

The other aspect of Holland's' theory is the environmental model. Here too are 6 differentiated areas based on those elements believed to represent the most common work environments. These 6 environmental models correlate with the 6 personality types outlined above: realistic, investigative, artistic, social, enterprising and conventional (Holland, 1997).

The specific adjectives used to describe these 6 environmental types are the same as those used to describe the corresponding personality types. So for instance, the adjectives describing an investigative personality (curious, intellectual, etc.) would also be used to describe an investigative environment. Holland's hypothesis was that a specific environmental model attracts a personality type that mirrors the attributes of that model. He also postulated that the specific environment will reinforce personality traits and behaviors characteristic of the model (Holland, 1997).

This closed loop reinforcement pattern is the foundation of Holland's belief that by determining an individual's personality, one would be better able to match an occupation to that person that would result in greater satisfaction, longevity and productivity. Following again Holland's typology, it is felt that STEM majors most closely match the characteristics of an investigative environment, so students with characteristics of an investigative type personality, particularly those having a strong investigative personality, would most likely seek a major correlating with that type. Indeed, it is hypothesized that students may self-select into specific STEM majors (mathematics or technology over science or engineering) based on the strength of their investigative personality.

Holland's theory is not without detractors. In particular, Tinsley (2000) found that while the person-environment model "provides a valid and useful way of thinking about the interaction between the individual and environment" (p. 173), the lack of research showing the efficacy of this model compared to others on person-environment fit weakens the strength of the model. Tinsley also noted that, in his analysis, the 6 personality and environmental profiles formatted by Holland into a hexagonal model do not adequately address the magnitude of the personality-environment fit.

In a similar vein to Tinsley's' concern about the person-environment model, Tracey (2007) took exception to the use of interest and college major as indicators of occupational outcomes (ultimate career goals) believing that college majors can in no way approximate the actuality of the occupation. In his overview of moderators of congruence between interest and occupation, Tracey also found that personality measures do not often enough account for flexibility in personality. Meaning that students having a personality score that is not predominantly one type or another, show more flexibility in personality and might then consider a larger pool of potentially interesting occupations (majors) from which to choose compared to students with less flexible personalities.

Although concerns expressed by these researchers warrant inclusion, the overall success of Holland's theory, and the RIASEC system, as evidenced by the years of research utilizing the theory speaks compellingly of the worthiness of Holland's work as a framework for studying how personality might impact a student's choice of major. Indeed, educational researchers using Holland's theory argue that the idea of person-environment congruence is applicable to students and their choice of majors since majors within specific disciplines will have personalities similar to the ultimate career for which that major prepares the student. Even given the shortcomings inherent in any model trying to determine the choices made by humans, the empirical evidence in numerous studies of the validity of this model makes it an appropriate choice for this study.

In addition to research on the role of personality in education, studies are beginning to produce evidence that personality models may have some significance in determining student motivation and success at college (Komrraju & Karau, 2005; Loundsbury, Saudargas, Gibson & Leong, 2005; Trapmann, Hell, Hirn & Schuler, 2007). Motivation can be considered one element of personality, and success can be attributed to choices made by students, so research in this area has a bearing on how personality relates to college major choice.

What we are also seeing in personality research is evidence that Holland's theory of vocational choice and the five-factor model appear to share many elements regarding the ability of each to help explain specific actions of students such as choice of major, although no study concludes that the two are interchangeable (DeFruyt & Mervielde, 1996, Barrick, Mount, & Gupta, 2003). The decision to use one model over the other depends on what aspect of the educational experience one is attempting to explain.

For example, in a longitudinal study on 934 students, DeFruyt and Mervielde (1996) looked at the differences and similarities between Holland's theory and the big five (five-factor) model in terms of academic achievement and student differences based on major chosen. These authors noted that while Holland's theory provides a method for predicting results based on person-environment fit, the five-factor model does not. They conclude from these findings that each plays a unique role in helping to understand aspects of a student's experience at college. Whereas Holland's theory might better explain "educational streaming" for students, the five-factor model better explains academic achievement.

Studies using Holland’s personality typology have generally supported the concept that personality traits impact a student choice of major. Pike’s study (2006) on students’ college expectations suggested that personality plays a role in what those expectations are and subsequently, what major a student chooses based on the expectations. The Feldman, Ethington and Smart (1999) study on how the congruence of personality-environment fit might affect change in students during their college years—the expectation being that students most congruent in personality-major choice would show the greatest improvement in specific abilities related to their personalities—indicated a significant effect for some of the personality groups but less effect for others. Porter and Umbach (2006) studied the overall effect of person-environment fit on choice of college majors in general and found that personality “was extremely predictive of student’s college major” (p. 445). There is considerable support in the literature regarding the existence of the personality types named by Holland. In fact, “the majority of all career-interest inventories use some version of the Holland scales” (Nauta, p.18)--the framework for which comes from the six personality types--including the precursor to the ACT Interest Inventory (Nauta, 2010).

CHAPTER III

METHODOLOGY

The following research questions guided this study:

1. Are students classified as a strong investigative personality type more likely to enroll in STEM (science, technology, engineering, mathematics) majors than students classified as a weak investigative personality type?
2. Are there differences in their likelihood to enroll in STEM majors among students of investigative-social, investigative-artistic and investigative-enterprising personality types?
3. What effect does personality have on students' self-selection into a biological versus a physical STEM major?

The methodology used to test each of these questions is presented in this chapter. The chapter is divided into three sections: (a) data source, (b) variables and (c) analytical procedures.

Data Source and Subjects

The data for this quantitative study came from the 2008 freshman Cooperative Institutional Research Program's (CIRP) survey results at a large university located in the southwestern region of the United States. This university enrolls more than 30,000 students and has a Carnegie Classification of a research university with high research activity (RU/H).

The overall sample from this secondary database included 2,745 respondents. Of these respondents, 58% were female and 42% were male. There were 9 original categories of race/ethnicity that I decided to compress into 6 by combining Mexican, Latino and Other Latino into one category called Latino. Additionally, the Asian and Pacific Islander categories were combined to form the single category Asian/Pacific Islander. The resulting percentages from these combined categories were: 70% White, 12% African American, 6% Asian, 14% Latino, 3% American Indian and 3% Other. Complete descriptive statistics for the respondents are listed in Table 1.

The CIRP survey was started in 1966 through support of the American Council on Education and is currently hosted in the Higher Education Research Institute at UCLA. Since initiation of the survey, 13 million students at 1900 private as well as public, 2 and 4 year institutions have provided information on constructs such as “learning strategies, academic achievement, interactions with family and peers, values and goals and patterns of behavior” (Higher Education Research Institute, 2010).

The 2008 survey asked respondents to rate themselves “as compared with the average person your age” on 18 different abilities such as writing, drive to achieve or popularity. The scale was 1 to 5, with 1 being *lowest 10%* and 5 being *highest 10%*. Five additional “diversity ratings” in this section asked the respondents to assess such things as “ability to see the world from someone else’s perspective” or “ability to work cooperatively with diverse people.” The scale for these items was 1 to 5, with 1 being *lowest 10%* and 5 being *highest 10%*. Respondents were also asked to “indicate the importance to you personally of ” 20 items related to “influencing the political structure,” “becoming successful in a business of my own” or “writing an original work.” The scale for questions in this area was 1 to 4, with 1 being *not important* and 4 being *essential*. Additionally, respondents were asked “How often in the past year did you?” on 12 questions related to habits of the mind such as “support your opinions with a logical argument”, take a risk because you feel you have more to gain” or “accept mistakes as part of the learning process.” The scale for this set of questions was 1 to 3, with 1 being *not at all* and 3 being *frequently.* Finally, respondents were asked about their “best guess as to the chances you will” do one of the following types of things while in college: “join a social fraternity or sorority,” “participate in student government” or “work on a professor’s research project” using a scale of 1 = *no chance*, 2 = *very little chance*, 3 = *some chance* and 4 = *very good chance.*

Using SPSS statistical software, factor analysis was utilized to construct 4 personality scales from the survey items mentioned above, based on Holland’s typology (Holland, 1985). Factor analysis is a method used by researchers to help explore and determine relationships or patterns among variables. By looking at the correlation between measured items it is possible to determine which set of items might be describing the particular construct of interest (DeCoster, 1998). Once a pattern has been established among those items, the items are grouped into “factors” that become a new variable from which data is derived (Vogt, 2007). The 4 personalities as defined by Holland are: a) investigative, b) artistic, c) enterprising and d) social. I chose to utilize only four of the six Holland personality types as both the CIRP survey questions and the Classification of Instructional Programs offer only very limited ability to differentiate the realistic and conventional personality types. Additionally, in the work on person-environment congruence and choice of major, Feldman, Ethington and Smart (2001) found that only these four Holland personality types had an impact on student choice of major.

Structuring of the personality types via analysis of the CIRP survey questions resulted in 5 items defining artistic personality, 7 items defining enterprising personaltiy, and 8 items each for social and investigative personalities. Items chosen for the personality scales, with the factor loading for each item, are listed in the appendix along with the Cronbach's alpha reliability index for each scale. Results from studies on personality and major choice using CIRP survey questions (Feldman, Ethington & Smart, 2001; Feldman, Smart & Ethington, 1999; Nicholls et al. , 2007; Porter & Umbach, 2006) confirm the validity of scales developed from these items for determination of personality type. These results suggest that the scales being developed using the CIRP survey items may present valid representations of the personality types outlined by Holland's theory.

Reponses to the CIRP survey items utilized for each of the personality scales were converted to *z*-scores with a mean of zero and a standard deviation of 1. Classification as one of the four personality types named above was determined by the mean of the z-scores of all items utilized for defining that personality. In other words, the investigative personality type utilized 8 items as definers of that type, so the mean of the z-scores of all 8 items was utilized to indicate the strength of the individual's investigative personality.

Variables

The dependent variable for the study was enrollment in STEM versus non-STEM majors. In order to answer question 3 of the study, STEM major was further classified into a biological or physical science major, based on definitions provide by the

Classification of Instructional Programs 2000 (NCES, 2010). In addition to the CIP definitions for STEM in general, the two groups of biological or physical STEM majors were determined by grouping majors based on whether the major was a life science (biology, microbiology, or environmental science, etc.) or a science with a large mathematical foundation (physics, chemistry, engineering, etc.) The freshman survey asked respondents to choose their probable major from a list of academic disciplines and majors. Respondent choice in this area was used to determine placement into a STEM versus non-STEM major, as well as placement into one of the two classifications of STEM noted previously. The independent variables included student high school GPA, socioeconomic status (SES), race/ethnicity, gender, and personality type. High school GPA was recoded from 8 grades levels to 4 by combining all "A" levels into one, all "B" levels into one and all "C" levels into one. I decided to recode income into the new variable SES by combining the available levels of income from the survey into commonly accepted definitions of low to high income status (Thompson & Hickey, 2005). While the usual definition of SES includes information about education and occupation, it can be argued that the ultimate predictor of SES in the United States is income. Higher levels of education are typically associated with occupations that generate higher income, but since this is not always the case, I chose to include income alone as an indicator of SES. Specific information on variable recoding is provided in Table 2.

Personality scales were constructed from standardized item scores. In the first step of constructing the scales, each item that made up the personality scale was individually transformed into a *z* score. I then calculated the average of the items within each personality scale to arrive at the four personality scores. Because of the nature of z scores, each personality scale has a mean close to 0 and standard deviation close to one. Table 1 shows the *n*, mean, and standard deviation of each personality scale. Because of item non-response, each personality scale ended up with a different *n*: investigative personality (*n* = 2638), artistic personality (*n* = 2643), enterprising (*n* = 2590) personality, and social personality (*n* = 2581). In order to further quantify investigative personality into “strong” and “weak” categories, students who had an investigative personality score equal to or above +1 were designated as strong and those with a score equal to or below -1 were designated as weak. The reason I chose +1 and -1 was because they represented one standard deviation above and below the mean. Those respondents who had a score between +1 and -1 were considered a moderate investigative personality type. Final recoding resulted in a dichotomous variable for a strong versus not strong investigative personality. Descriptive statistics for this personality type is found in Table 4.

For the second research question, I created additional qualifications for personality type in order to capture the combination of personality types. Three combination personality qualifications were created: (a) investigative-social, (b) investigative-enterprising, and (c) investigative-artistic. Students who had a score higher than 0 on both the investigative and social personality scales were classified as investigative-social. Similarly, students who scored higher than 0 on both the investigative and enterprising personality scales were classified as investigative-enterprising; and students who scored higher than 0 on both the investigative and artistic personality scales were classified as investigative-artistic. By offering a more nuanced definition of personality this study would examine not only the role of investigative personality in choosing a STEM major choice, but also the effects of other personality types in the student's self-selection into STEM majors. Descriptive statistics for each of these personality types is found in Table 1.

Analysis

Descriptive statistics were used to examine the demographic characteristics of the respondents. The multiple independent variables in the study and one dichotomous dependent variable for the three research questions dictated use of binary logistic regression as an appropriate analytical method for answering those questions. For the purpose of this study, logistic regression helped predict which of the independent variables might have the greatest influence on student self-selection into STEM majors by providing an odds ratio of the effects of the independent variables on the dependent variable (Pallant, 2007). In other words, this type of analysis created an estimate of the probability that a particular event will occur, given a specific set of variables (Sweet & Grace-Martin, 2002). Logistic regression does not assume a linear relationship between the independent and dependent variables (Field, 2009). This advantage is especially important when studying educational or sociological conditions since events impacting subjects in these areas do not always occur in linear patterns. In addition, logistic regression provides information on the sensitivity and specificity of the study's model, and the "goodness of fit," or effect size, of this model for explaining the role of personality in STEM major enrollment (Garson, 2010; Pallant, 2007). I calculated the effect size by comparing model chi-squares for the regression on each question. Additional discussion on this technique is provided in chapter VI.

Summary

This chapter restated the research questions guiding this study. Information regarding the secondary data source for the sample was presented, and general demographic information of the sample was discussed. Development of the personality scales utilized in the study was presented along with their reliability tests. Procedures followed for recoding the data in preparation for analysis were delineated. Finally, the analytical methodology for each research question was introduced. Results of the data analysis are discussed in chapter IV.

Table 1

*Descriptive Statistics for Respondents (*N *= 2,745)*

	N	Percentage	Range	Minimum	Maximum	Mean	Std. Deviation
Gender							
Male	1,145	42%					
Female	1,589	58%					
Race/Ethnicity							
White	1,920	70%					
African American	323	12%					
Native American	83	3%					
Asian/Pacific Islander	173	6%					
Latino	396	14%					
Other	78	3%					
STEM major							
Yes	542	21%					
No	2,095	79%					
No response	108	4%					
STEM categories							
Biological STEM	281	10%					
Physical STEM	261	9.5%					

Socioeconomic status							
Low	555	20%					
Low-middle	697	25%					
High-middle	1090	40%					
High	245	9%					
High school GPA	2726		2.00	2.00	4.00	3.48	.52
Personality Type							
Investigative	2,638		3.42	-2.30	1.12	.0022	.57
Enterprising	2,590		3.70	-2.25	1.46	.0000	.61
Social	2,581		3.63	-2.07	1.56	.0020	.64
Artistic	2,643		3.35	-1.53	1.81	-.0022	.70
Investigative Artistic	738		1.00	0.0	1.00	.2842	.44
Investigative Enterprising	808		1.00	0.0	1.00	.2944	.46
Investigative Social	780		1.00	0.0	1.00	.2689	.45

Table 2

Descriptions for Recoded Variables Used in Logistic Regression

Variable	**Description**
STEM Major	Dependent variable STEM = 1; non-STEM = 0 Indicates intent to major in a STEM field
Biological versus physical STEM	Dependent variable Biological = 1; non-biological = 0 Indicates intent to major in a biological STEM field Biological STEM = life sciences such as biology, environmental science, microbiology, marine science, etc. Physical STEM = science requiring heavier math emphasis such as engineering, physics, chemistry, etc.
High school GPA	Self-reported grade from eight categories: A/A+, A-, B+, B, B-, C+, C, D. Recoded as an interval variable: All A's =4, all B's =3, all C's = 2, D=1.
Socioeconomic status	Self-reported family income ranging from less than $10,000 to greater than $250,000. Recoded as an interval variable: low (<10,000 to $39,999) = 1,Low middle ($40,000 to 74,999) = 2, high middle ($75,000 to 199,999) = 3, high (> $200,000) = 4.
Gender	Dummy variable. Male = 1; female = 0.
Personality Type	Standardized measures for four scales as listed in the appendix.

CHAPTER IV

RESULTS

The purpose of this study was to examine the effect of personality on a student's self-selection into science, technology, engineering and mathematics (STEM) majors. Also intended was an investigation of how a strong association with the investigative personality type, or association with a combined investigative personality type, moderates a student's choice of major. In addition, an examination was made of the effect of personality type on enrollment into specific STEM majors. Presented in this chapter are the results of the data analysis for the three research questions. Demographic information on the independent variables, descriptive statistics for the personality scales and STEM majors, and information on scale reliability are listed in Table 1 and the appendix as noted in chapter III.

Missing Data

Prior to examining the results of the analyses of each the research questions, I would like to offer a brief discussion on the missing values analysis. As noted by Newton & Rudestam (1999), missing data are unavoidable in survey research for a number of reasons. When using a survey such as the Cooperative Institutional Research Program (CIRP), missing data would occur when respondents simply ignore or refuse to answer a given item. The problem of missing data, of course, is that inferences may be made on data that is biased in some way because of that missing data. I conducted a missing values analysis and the results are presented in Table 3. While imputation, which estimates missing values for future use in data analysis

(Newton & Rudestam, 1999) is considered superior to tactics such as list-wise deletion, it is not without difficulties. For instance, use of imputation requires an assumption of random missing values whereas list-wise deletion might be used when a small percentage of values are missing (Newton & Rudestam, 1999). The missing data analysis results indicated that income has one of the highest levels of missing data, but it is still less than 6% of the total. The 4 created personality scales also have missing data, again at 6% of the total or less. Likewise, both gender and STEM majors have some values missing from respondents, with gender having a miniscule amount and STEM with less than 4% of the total number. It could be argued that a majority of freshmen entering college are not aware of parental income, making a deficiency in this area unfortunate, but not particularly significant for the study results. Additional information gained from the results of a Little's MCAR (missing completely at random) test of means suggests that use of this data, as is, would be an acceptable approach for providing unbiased results (SPSS, 2007). When a Little's MCAR test has a significance value of 0.05 or less, the data is not considered to be missing completely at random (SPSS, 2007).

Results from this analysis indicated that $p = 0.067$, which is close enough to the cut off of $p = 0.05$ to merit consideration that the data is not missing completely at random. Newton and Rudestam (1999) suggested that using imputation is a legitimate technique for dealing with missing data if the researcher can be confident that the pattern of missing data seen is truly random. A value this close to the level of significance needed to make that determination warrants caution when deciding how to manage missing values. Consequently, I decided not to use imputation for my missing data but rather to allow SPSS to use list-wise deletion.

Table 3

Percentages of Missing Values per Variable with Summary of Means and Little's MCAR Test

	N	Mean	*SD*	Missing Count	Missing Percent	No. of Extremes Low	No. of Extremes High
Income	2587	8.9	3	158	5.8	61	0
Investigative	2638	0	.57	107	3.9	6	0
Enterprising	2590	0	.61	155	5.6	3	0
Social	2581	0	.64	164	6.0	2	0
Artistic	2643	0	.70	102	3.7	0	0
Gender	2734	0		11	.4		
STEM	2637			108	3.9		

Means Income	Means INV	Means ENT	Means SOC	Means ART	Little's X^2	Little's DF	Little's *p*
8.93	.0018	-.0059	-.0045	-.0070	72.58	56	.067

Research Question 1

Question 1: Are students classified as a strong investigative personality type more likely to enroll in STEM (science, technology, engineering, mathematics) majors than students classified with a weak investigative personality type? Descriptive statistics for these personality types are available in Table 4. Results of the logistic regression for this question suggest that characterization as strong versus a weak investigative personality was not significant (p = .283). Previous research (Chen & Simpson, 2012) asking what effect personality had on student self-enrollment into STEM majors suggested that a student with an investigative personality was 1.5 times more likely to enroll in a STEM major than those not designated as investigative. The result of this analysis appears to indicate that further delineation of an investigative personality into "strong" versus "weak" by decreasing the number of respondents meeting that criteria does not tell us any more about how strength of personality impacts students self-selection into STEM. In fact, the small sample size created by delineating investigative personality in this manner resulted in fewer variances within the data compared to the whole population, which was a probable factor in the non-significant result seen. Implications of this finding are discussed further in chapter VI.

Table 4

Descriptive Statistics for Strong Personality Type

	n	Minimum	Maximum	Mean	S.D.
Strong Investigative	115	1.00	1.12	1.1172	< .001
Weak Investigative	81	-2.3	-1.00	-1.3209	.24746

Additional findings from this analysis suggest a number of other variables as significant predictors of student self-selection into STEM majors. Being Asian ($p < .001$) or African American ($p = .003$) are a significant predictors of student self-selection into STEM majors, as was gender ($p < .001$). In fact, all else being equal, Asian students are 2.3 times more likely than White students to self-select into STEM, while African American students are 1.2 times more likely. Moreover, after controlling for other variables, male students are 1.9 times more likely to self-select into STEM majors than females. Also, a one-point increase in GPA would increase the likelihood of self-selection into STEM majors by 1.4 times while socioeconomic status (SES) appears to have a negative effect on self-selection into STEM majors. Results suggest that for every increase in SES, students are less likely to self-select into STEM majors by a factor of 1.15.

An important element in any modeling statistical analysis is determination of effect size to provide information on the amount of variance attributable to a given variable(s). Given the lack of consensus on the best measure of effect size in logistic regression, I chose to use a comparison of the model chi-squares, determined by the difference between the -2 * log likelihoods of each model step. This method provides an estimate of the model fit similar to that of the *F* test in multiple regression (Hair et al., 2010).

Table 5

Summary of Logistic Regression Predicting Self-Selection into STEM Majors for Strong Investigative Personality

				Odds	95% C. I.	
Predictor	*B*	S. E.	*p*	Ratio	Lower	Upper
Black	.455	.154	.003	1.58	1.166	2.132
American Indian	-.104	.297	.727	.901	.504	1.612
Other	.345	.299	.249	1.4	.786	2.538
Asian Pacific Islander	.823	.178	<.001	2.28	1.607	3.227
Latino	-.178	.156	.256	.837	.616	1.138
Gender	.641	.103	<.001	1.9	1.551	2.325
Socioeconomic status	-.141	.057	.014	.868	.776	.972
GPA	.300	.100	.003	1.35	1.109	1.642
Strong Investigative	.257	.240	.283	1.29	.809	2.069
Constant	-2.480	.393	<.001	.084		

The variance in the model was 2424. 89 for the first block, which included the variables gender, GPA, race, and socioeconomic status, compared to 2422. 98 for the second, which added the variable strong personality, giving a X^2 = 1.11 (p < .001) for this model. These findings would suggest that while the model is overall useful, because of the level of significance, for determining the effect of gender, race, GPA, and socioeconomic status on self-selection into STEM majors, the addition of strong investigative personality as a variable adds no meaningful information to our understanding of these predictors. Full results of the analysis can be found in Table 5.

Research Question 2

Question 2: Are there differences in their likelihood to enroll in STEM majors among students of investigative-social, investigative-artistic, and investigative-enterprising personality types? Again, descriptive statistics for the personality types are provided in Table 1 Two combined personality types, investigative-artistic (IA) (odds ratio = .44, $p < .001$) and investigative-social (IS) (odds ratio = 1.42, $p = .019$) were statistically significant for predicting whether a student characterized as a combined investigative personality self-selects into a STEM major. A student not characterized as an investigative-artistic personality is 2.3 times more likely to self-select into STEM majors than one considered investigative-artistic, while a student having an investigative-social personality is 1.4 times more likely to self-select into STEM majors, all else being equal. Given that prior research (Chen & Simpson, 2012) indicated that an investigative personality would be more likely to self-select into STEM majors, it is not surprising that a personality type combined with investigative would also be more likely to enroll in STEM. What is interesting is that the combination with the greatest likelihood of enrollment in STEM is investigative and social personalities. Further discussion on the implications of this result is provided in the next chapter. As in the analysis for question 1, gender, race, SES and GPA are significant predictors of student self-selection into STEM, even given the addition of combined personality types to the model. A comparison of variance for this model showed 2424.09 for the first block, using the variables of gender, race, GPA, and socioeconomic status, and 2390.28 for the second, which adds the variable for combined personality type, resulting in a χ^2 = 33.81 (p < .001). This suggests that the model is a good fit for explaining the effect of combined personality on student self-selection into STEM majors.

Full results of the analysis are presented in Table 6.

Table 6

Summary of the Logistic Regression Predicting Self-Selection into STEM Majors for Combined Personality Type

Predictor	***B***	**S. E.**	***p***	**Odds Ratio**	**95% C. I Lower**	**Upper**
Black	.451	.156	.004	1.570	1.157	2.130
American Indian	-.092	.300	.758	.912	.506	1.642
Other	.409	.300	.173	1.505	.836	2.710
Asian Pacific Islander	.804	.180	< .001	2.235	1.572	3.179
Latino	-.194	.158	.219	.824	.605	1.122
Gender	.685	.105	<.001	1.984	1.616	2.437
Socioeconomic status	-.142	.058	.014	.868	.774	.972
GPA	.311	.101	.002	1.365	1.119	1.664
Investigative social	.349	.148	.019	1.417	1.060	1.896
Investigative enterprising	.012	.141	.935	1.012	.767	1.334
Investigative artistic	-.812	.147	<.001	.444	.333	.592
Constant	-2.433	.397	<.001	.088		

Research Question 3

Question 3: What effect does personality have on students' self-selection into biological versus physical STEM majors? Again, descriptive statistics for the personality types are presented in Table 1. Results of the logistic regression for this question suggest that one personality type, enterprising (odds ratio = 1.5, p = .042), is a significant predictor of student self-selection into a biological STEM versus a physical STEM. Those students characterized as an enterprising personality are 1.5 times more likely to enroll in a biological STEM over a physical STEM, all else being equal. Implications for this finding are discussed in the next chapter. Of interest, neither GPA nor socioeconomic status are significant predictors of self-selection into these specified STEM groups, suggesting that while these variables may help predict a student's enrollment in STEM overall, neither contribute to increasing our understanding of why a student enrolls in one type of STEM major over another. Asian (odds ratio = 4.34, $p < .001$) and African American (odds ratio =2.33, p = .018) races are both significant for predicting whether a student enrolls in biological STEM versus physical STEM with Asian students being 4 times more likely, and African American students 2 times more likely to enroll in biological STEM versus White students, all else being equal. There was no difference statistically between Whites and American Indians, Latinos, or Others for self-selection into biological versus physical STEM majors. Also of interest, was the finding that gender remains a significant predictor of enrollment in a STEM major with males much less likely than females to enroll in a biological versus physical STEM major. With all else equal, females are about 8.5 times more likely to enroll in biological STEM majors than males. Further discussion of this finding is presented in the next chapter. Comparison of variance in the model shows 501.86 for the first block, which includes gender, race, GPA, and socioeconomic status, and 489.84 for the second block, which adds personality type for biological versus physical STEM majors, resulting in a $X^2 = 15$ ($p < .001$) for the model. This finding suggests that knowing personality type contributes somewhat to our understanding of why student's self-select into specific types of STEM majors. Details of the analysis are presented in Table 7.

Table 7

Summary of Logistic Regression Predicting Self-Selection into Biological versus Physical STEM Majors

				Odds	95% C. I.	
	B	**S. E.**	***p***	**Ratio**	**Lower**	**Upper**
Gender	-2.134	.242	<.001	.118	.074	.190
Socioeconomic status	.171	.127	.177	1.187	.925	1.522
African American	.846	.359	.018	2.331	1.153	4.713
American Indian	.123	.585	.833	1.131	.359	3.558
Other	-.006	.586	.992	.994	.315	3.137
Asian/Pacific Islander	1.467	.401	<.001	4.338	1.975	9.528
Latino	-.247	.352	.482	.781	.392	1.556
GPA	-.253	.224	.260	.777	.500	1.205
Investigative	-.344	.226	.128	.709	.455	1.105
Enterprising	.434	.213	.042	1.543	1.016	2.344
Social	.348	.199	.079	1.417	.960	2.091
Artistic	.013	.201	.947	1.013	.683	1.503
Constant	1.543	.874	.078	4.677		

Summary

In chapter IV, information on the results of a missing data analysis explained the reasoned choice for not using any imputation techniques as a corrective device for the data used in this study. Results from research question 1 indicated a lack of significance for differentiating the investigative personality type into the designation of "strong" or "weak" investigative personality. It was noted that prior research had shown significance for the investigative personality as an important factor in a student's choice of major, and there does not appear to be a benefit from attempting to narrow the range of respondents meeting the definition of that personality type. Results from analysis of the second research question revealed that two combined personality types, the investigative-social and investigative-artistic, had significance in student self-selection into STEM majors, all else equal, as did gender, SES, and GPA. Two racial groups Asian and African American showed significance versus White for enrollment in STEM although the remaining racial designations were not significance. Results from the third research question provided additional information on student self-selection into specific types of STEM majors. One personality type was found to have an effect on a student's choice of STEM major. The enterprising personality was found to have significance when determining a student's self-selection into biological over a physical STEM majors. The remaining personalities did not appear to have significance for this delineation. Of note was that SES and GPA did not have significance as predictors for student enrollment in a specific STEM major and while gender showed significance, that predictor indicated that males were much less likely than females to enroll in biological STEM versus physical STEM. A discussion on the implications of these results is presented in chapter V.

CHAPTER V

DISCUSSION

The purpose of this study was to examine the relationship between personality and a student's self-selection into science, technology, engineering and mathematics (STEM) majors. Specifically, this study sought to explain the effect that strength of personality type might have on self-selection into STEM majors, as well as the effect that a combined personality type might have on student selection of these majors. In addition, this study examined the effect of personality type on student self-selection into specific types of STEM majors, denoted as biological or physical STEM. Despite continued financial support for STEM programs such as Project Lead the Way or the National Math and Science Initiative, which are designed to increase student enrollment in STEM majors, the United States continues to show lack of growth in these areas compared to other developed countries (National Academies, 2007). In elucidating reasons for student choice in selecting a STEM major over other majors, this study was able to bring increased awareness to the role of personality as a predicting factor in that choice.

This chapter provides a summary of the study and a discussion of the findings, with implications of the findings for adding to our understanding of how best to increase the number of students in the United States entering STEM majors. The limitations of the study, as well as recommendation for further research to expand on the study findings, are also presented. Finally, conclusions regarding support, or lack thereof, of the intended purpose of this study are presented.

Summary of the Findings

Using Holland's (1997) theory of vocational choice as a theoretical framework, this study investigated three questions related to personality and a student's self-selection into STEM majors: (1) Are students classified as a strong Investigative personality type more likely to enroll in STEM (science, technology, engineering, mathematics) majors than students classified as a weak investigative personality type? (2) Are there differences in their likelihood to enroll in STEM majors among students of investigative-social, investigative-artistic, and investigative-enterprising personality types? (3) What effect does personality have on students' self-selection into a biological versus a physical STEM major?

Secondary data gathered from the freshman CIRP 2008 survey at a large research university served as the basis for developing the 4 personality scales used to examine those questions. Selection criteria for the items used included a factor loading of .30 or greater. Reliability of the scales was established with Cronbach's alpha's of greater than .70 for each scale. All three questions were answered quantitatively from the results of logistic regression on the means of the z-scores for the personality scales. Each regression controlled for the variables of race, gender, socioeconomic status and high school GPA. Findings from the analysis included determination of effect size through calculation of chi-square for each model.

The study included 2,745 respondents with nearly three-quarters of the sample being White, and almost 60% being female. Descriptive statistics regarding the exact breakdown of race and gender was provided. Personality types were quantified in three ways. For the first question, strength of personality was determined by a respondent's standard deviation score of +/- 1 from the mean of zero. The second question regarding combined personalities required quantification of type using the respondent's z-score means of greater than zero for both scales in question. The final question was quantified by using the respondents' mean of all the item z-scores for a given personality scale.

Discussion and Implications

Question 1: Strong Investigative Personality

This study explained the effect of a strong investigative personality on student self-selection into STEM majors, controlling for gender, race, socioeconomic status and high school GPA. The odds ratio for strength of personality affecting a student's self-selection into STEM was determined via logistic regression (Voght, 2007). The *p*-values, utilizing a $p < .05$, determined statistical significance (Pallant, 2007). Calculated chi-squares for effect size, as well as means and standard errors were reported in chapter IV.

It is apparent from the results of this study that designation as a strong investigative personality has no bearing on whether a student self-selects into a STEM major. What is surprising about this finding is that the theory proposed by Holland (1997) suggested that it is the associated strength of a particular personality type as well as the type itself that determines congruence with a given career. Prior research on the effect of personality on STEM enrollment (Chen & Simpson, 2012) showed that having an investigative personality was a strong predictor of that enrollment, so this finding may seem a bit contradictory at first blush. However, one possible explanation is that the instrument used for determining the personality type was not adequate for that role. Although factor analysis on the items selected for each personality scale indicated that the items used, together with the reliability scores for the scales developed, were more than adequate, the CIRP survey is not intended to be a personality determinate. For example, current understanding of what defines personality includes having information regarding an individual's beliefs, values, and goals (John, Robins & Pervin, 2008). While it is reasonable to assume that a survey that incorporates questions designed to elicit information in these areas would be an appropriate forum from which to develop a personality scale, the inherent subjectivity of doing so can impact results in unexpected ways.

Another possible explanation is that using a +/- 1 standard deviation from the mean of zero is not a sensitive enough method to indicate personality strength. Other research on investigative personality and STEM showed that respondents with a mean greater than zero on that personality scale were more likely to enroll in STEM majors than students with a mean less than zero (Chen & Simpson, 2012). One of the definitions for personality in this study indicated that a moderate personality would fall between a +1 and -1 standard deviation from the mean of zero. What was not determined in this research is what the best cut-off point would be for designating a strong versus a moderate or weak investigative personality type. Lack of a specific determining cut off point could explain the lack of significance found for this question. The implication of this is that more research is needed to determine what that cut off point might be in order to further our understanding of how strength of personality impacts a student's self-selection into STEM majors.

One of the main criticisms of Holland's theory is that it does not adequately account for flexibility in personality (Tracey, 2007). These findings may lend support to the concerns of that researcher, in suggesting that one should not narrowly define a personality type when attempting to determine likelihood of self-selection into STEM majors.

The findings from this study, consistent with much of the literature on STEM enrollment (Briggs, 2006; Campbell, Jody, Hoey & Perlman, 2002, Pike, 2006, Porter & Umbach, 2006) indicated that gender, race, socioeconomic status and GPA are all strong predictors of self-selection into STEM. Indeed, results showing that males are almost twice as likely than females to enroll in STEM, or that Asians are twice as likely, versus Whites, to enroll in STEM, are not surprising given the plethora of literature with similar findings (Chen & Weko, 2009; George, et al., 2001). While results also indicated that African Americans are more likely than Whites to enroll in STEM, there was no difference between Whites, Hispanics and Native Americans. Although this finding contradicts a report from the National Science Foundation (2003) showing that Hispanics have one of the largest increases in STEM enrollment, it may suggest that the work being done to increase minority representation in STEM majors is at least partially effective.

Results of the analysis also suggest that students from a higher SES are less likely to enroll in STEM than those with lower socioeconomic status. Conflicting results for research on this predictor for student choice of major makes it difficult to determine a reason for this finding. Some studies (Briggs, 2006; Campbell, Jolly & Perlman, 2002) suggest that SES is a predictor for student choice of college major, while others (Christie, Munro & Fisher, 2004) found that SES was not significant for that choice. One could speculate that students from higher SES do not see STEM as a viable option for meeting the goal of attainment, and management, of the wealth needed to maintain a higher SES. These results add to the current disagreement over the role of SES, with results tending to support those studies showing SES as a predictor of student self-selection into STEM majors.

Question 2: Combined Personality Type

This study examined the effect of a combined investigative personality type on student's self-selection into STEM majors, while controlling for gender, race, SES, and GPA. The odds ratio for the likelihood of a combined investigative personality affecting a student's self-selection into STEM was determined via logistic regression (Voght, 2007). The *p*-values, utilizing a $p < .05$, determined statistical significance (Pallant, 2007). Calculated chi-squares for effect size, as well as means and standard errors were reported in chapter IV. Results of this study suggest that students characterized as an investigative-social personality are 1.4 times more likely than other personality types to enroll in a STEM major, even controlling for race, gender, socioeconomic status and GPA. This finding may seem somewhat perplexing given one of the foundational principles of Holland's (1997) theory.

In order to graphically depict some of the ideas of his theory, Holland (1997) placed personality types on a hexagonal model in order to show the "psychological resemblances among personality types and environments" (p. 6). Personalities furthest away from each other have little in common, those closet on the hexagon have more in common. Under this schema, investigative and social personalities have, at best, a modest resemblance to one another. In addition, Holland (1997) defines investigative as being analytical, intellectual, rational, curious, or cautious, and defines social with adjectives such as agreeable, helpful, idealistic, empathic, or patient. It seems contradictory to have these personalities together reflect greater likelihood in enrolling in a major defined as one that “encourages people to see themselves as scholarly, as having mathematical and scientific ability” (Holland, 1997, p. 44).

This study did not differentiate which personality might dominate within the combination, so we cannot know if it is the investigative or social personality creating the greatest influence on student enrollment in STEM, or if both are equal contributors to the prediction. Prior research on the interaction between gender and personality (Chen & Simpson, 2012) may help explain the apparent conflict between the results seen in this study and the theory utilized for the study. According to Chen and Simpson (2012), gender interacts with personality, and this interaction influences a student’s decision to enroll in a STEM major. It is possible, given the results of that research showing females with a high social personality tend to be more likely to enroll in STEM majors than males with a high social personality, that the results seen in this analysis reflect a similar tendency. It is also possible that another element, such as particular type of STEM major, is impacting student choice.

Also noted in the study findings was that an investigative-artistic personality type is somewhat less likely to enroll in a STEM major than other personality types. This is a little surprising given that investigative and artistic personalities are closest to one another on Holland’s hexagon, indicating these personality types have commonalities (Holland, 1997). While both of these personalities can have elements of creativity, it is possible that a student associating with an artistic personality would tend to choose an "artistic occupation" that, according to Holland (1997), offers an opportunity to utilize their artistic skills. Consistent with results in the first research question, gender, race, socioeconomic status and GPA remain strong predictors of STEM enrollment. Other than the potential interaction between personality and gender noted above, there does not appear to be an impact on these variables as a result of the addition of the combined personality type. In other words, although the X^2 (33. 81) for this model showed a moderate effect with the addition of combined personality to the model, that addition did not impact for better or worse the effect of the other predicting variables.

Question 3: Personality Types and Specific STEM Majors

This study examined the effect of personality on student self-selection into either a biological or physical STEM major, controlling for gender, race, socioeconomic status and GPA. The odds ratio for the effect of personality on student's self-selection into a biological or physical STEM major was determined via logistic regression (Voght, 2007). The *p*-values, utilizing a $p < .05$, determined statistical significance (Pallant, 2007). Calculated chi-squares for effect size, as well as means and standard errors were reported in chapter IV. Results of this study confirm the role of gender as a predictor of student self-selection into STEM majors with an interesting twist. While results of the two previous research questions indicated that males are much more likely than females to enroll in STEM overall, these results indicate that males are much less likely (odds ratio = .118, $p < .001$) to enroll in biological STEM majors than females, all else equal. This finding is consistent with other research showing similar results (Briggs, 2006; Chen & Simpson, 2012, Chen & Weko, 2009). Despite trends towards greater inclusion of females in STEM overall, males continue to dominate in all areas of STEM (Chen & Weko, 2009) so a result showing female dominance in certain areas of STEM may signal an increased interest in females for these majors. It would be important to gather additional information regarding the ultimate goal of females entering the biological STEM majors in order to further illustrate the role of personality on self-selection into these majors.

Interestingly, both GPA and socioeconomic status did not show significance as predictors of self-selection into a biological STEM major, which is different from the results found in both research question 1 and 2. This may simply be that while GPA and socioeconomic status influence entry into STEM major in general, those variables have no effect on which STEM a major a student selects. In other words, having already determined that a STEM major is their correct choice, the further designation of what specific STEM major a student chooses is not important as part of the predictive equation.

Of note, African American (odds ratio = 2.3, p = .018) and Asian (odds ratio = 4.34, p < .001) students are much more likely than White students to enroll in biological versus physical STEM majors, all else being equal. It is no surprise that Asians were found to be more likely than Whites to enroll in STEM majors as past research on major choice corroborates this finding (NSF, 2003). As noted in Chen & Simpson (2012) recent findings from a national study showed that African Americans were also more likely to enroll in STEM, which is consistent with the findings in this study. Nevertheless, the finding of increased likelihood of student self-selection for these two racial groups into biological over physical STEM majors may have important implications for how we approach recruitment into those majors. Since our greatest need in the STEM pipeline currently is increased enrollment in physical STEM majors (Alfred, Shults, Jaquette, & Strickland, 2009), having additional information such as which STEM majors are being chosen by specific racial groups may help policymakers focus on improving mechanisms for stimulating interest in those majors less likely to be chosen.

In reviewing the impact of personality on the selection of a biological versus a physical STEM major, only the enterprising personality showed significance (odds ratio = 1.5, p = .042). This finding contradicts prior research (Chen & Simpson, 2012) and also contradicts findings from questions 1 and 2 of this research, where only the investigative or investigative-social personalities had influence on student self-selection into any STEM major. Information from Holland's theory (1997) would suggest that the enterprising personality is the least likely to enroll in any STEM major, regardless of specific type, given the defining features of that personality, so this result is a bit perplexing. However, certain elements of this personality may point to an explanation. The enterprising personality is one interested in being a community leader in a position of power. This personality is both confident and resourceful. It is possible that these results signify an increased likelihood of self-selection into a biological STEM by enterprising personalities because of the tendency for graduates of these majors to enter professional schools. Graduates of professional schools quite often become community leaders because of the status accorded them by their profession and hold at least relative positions of power. Quite often also, these graduates will pursue careers allowing them to establish their own business, which is a defining characteristic of the enterprising personality.

Although social personality did not meet the requirement for statistical significance (p = .079) and thus was not included in the results chapter, I believe this personality warrants further examination as a potential predictor of biological STEM enrollment. Given the results of Chen & Simpson (2012) showing an interaction between social personality and gender for self-selection into STEM majors, it would not be inappropriate to consider, even at the level of significance shown, that the social personality may have some influence on a student's self-selection into a biological STEM majors. One implication of this finding is that additional research, utilizing a standardized personality scale would be of benefit for further explanation.

Limitations

There are a number of limitations to this study. The first is the Cooperative institutional research program (CIRP) survey itself. As noted in chapter IV, this survey was not developed as a personality scale but rather as an information gathering mechanism on the many elements affecting a student's educational attainment. While the constructs determined by these items can be useful for examining a number of issues related to higher education, grouping individual items to define a particular construct such as personality is, by its very nature, a somewhat subjective undertaking.

Also, this study did not include longitudinal data on student's enrollment in STEM majors. It is arguable that freshman students choose a particular major with only a vague idea of the ultimate goal of their education, and so change that major prior to graduation. Much research has been done on possible reasons for students changing majors or even leaving college (Daempfle, 2002; Oseguera & Rhee, 2009; Simpson, 2001), so additional information focusing on personality as a possible explanation for student retention in, or attrition from, STEM majors would be an important contribution to our current knowledge.

In addition, the respondents for this study came from one large university in the southwest. While the sample size was adequate for the study, the use of one type of higher education institution limits the ability to generalize the findings beyond that single entity. Certain characteristics of that one institution, not present in other institutions from different locals, or having different educational missions, may change the tenor of the study.

Furthermore, respondents to the survey from this institution were predominantly white and female. Oftentimes, when answering surveys regarding perception of personal ability, females will rate themselves lower than males on the same scale, regardless of actual ability (Thebaud, 2010). Additionally, female response to surveys may corroborate socio-cultural influences on self-ratings estimates (Clack & Head, 1999). Thus results from this study may reflect the influence of these phenomena, as well as other societal influences arising from differing expectations of the two genders. Although a large percentage of respondents in the study rated themselves as above average on the scales utilized, this potential issue stills warrants consideration as a possible limitation. Also, while students can certainly have many characteristics in common, the differences between racial and ethnic groups, originating through social and cultural influences, creates enough variance in student perception and action that a sample made up largely of one specific group limits the ability to generalize beyond that group. Additionally, this study did not include students who might have been first generation or transfer students. Research on these groups suggests that there may be specific, and different, characteristics in these groups influencing their educational habits.

The particular classification method used to determine STEM versus non-STEM categories could also create a limitation for the study. While the Classification of Institutional Programs (NCES, 2000) list provides a number of examples of STEM majors, those classifications do not precisely match the 85 majors given as choices on the CIRP survey. Consideration must also be given to the fact that the majors provided on the CIRP survey do not mirror the actual majors offered at the university from which data for this study was taken. Depicting a student’s choice of STEM major under these circumstances may have resulted in a definition of STEM unique to this single institution, making the results of the study applicable only to that institution. Furthermore, the CIP uses one set of disciplines to define STEM, while other organizations, such as the National Science Foundation, use a much broader definition (Chen & Weko, 2009) creating inconsistencies in how STEM majors are perceived. It is conceivable that using a different set of criteria for defining STEM would produce different findings.

An additional limitation to the study concerns the division of STEM majors into only two specified groups. Initially, the STEM majors were divided into five categories: biological, physical, technology, engineering and mathematics. However, many of the categories had extremely low sample sizes, so the decision was made to combine those smaller groups (physical, engineering, technology and mathematics) into one large group labeled physical STEM. In doing so, it is possible that important characteristics of students from each of those smaller groups were obscured.

One final limitation to the study is that the personalities were not combined into the many different categories included in the full typology of the Holland (1997) model. It may be that different combinations of personality, such as enterprising-social, not associated with the investigative personality type, have a greater impact on student enrollment into STEM than those utilized in this study.

Conclusion and Recommendations for Further Research

Results of this research suggest that personality does have an effect on student self-selection into STEM majors, beyond that seen with gender, race, GPA or socioeconomic status. Policymakers can use this information to help expand the scope of current programs being used to increase enrollment in STEM. Through allocation of funds to methodologies for determining personality type during the early school years, we may be able to further stoke the STEM pipeline.

For instance, research on personality suggests that personality forms at an early age (John, Robins, & Pervin, 2008), thus our current habit of waiting until high school to counsel students on career goals may be shortchanging that STEM pipeline. Furthermore, the National Science Board (2010) recommends early recognition of potential STEM talent as a means of increasing the STEM pipeline. Since funding for education has become such a controversial topic, it might be feasible to piggyback on mechanisms already in place for evaluating middle-school students to facilitate this early recognition.

As an example, the ACT exam incorporates questions adapted from the Strong Interest Survey to provide students with an idea of how certain career options might fit their personal interests (ACT, 2012). Public schools in the United States could add a personality scale component to current outcomes tests that would offer a similar option. In doing so, these schools would provide educators and counselors with additional information that offers a more complete picture of appropriate career choices for a particular individual.

Results from this research mirrored findings in other studies regarding the impact of gender, race, socioeconomic status, and GPA on student choice of major, while showcasing the importance of adding personality as a factor in that decision. The implication is that although current research continues to confirm the role of various factors for predicting major choice, perhaps the time has come to broaden the scope of that research to include intrinsic as well as extrinsic factors for explicating all possible reasons for that choice. For instance, current programs for increasing representation of females and minorities in STEM majors focus heavily on external factors that create barriers for these individuals when seeking entry into STEM fields. According to Labov, et al. (2009) and the National Science Foundation (2003), efforts in these areas are only modestly successful. Incorporating information regarding the influence of personality may increase our understanding of how best to counsel students regarding college majors most likely to appeal to their individual values, beliefs and goals.

The recommendations for further research arise primarily from the limitations of the research. First, a more robust study would result with use of a large national database such as the Integrated Post-Secondary Education Data System (IPEDS) which collects a wide range of information such as race, gender, degree completion, number of credit hours, etc. on students from a variety of higher education institutions (NCES, 2012). In lieu of utilizing a single national database, consideration could be given to combining student data from a number of universities or colleges in a given region to increase the generalizability of the findings.

Additionally, studies to further investigate the role of personality and the possible interaction between personality and gender or race, as a determinate of self-selection into STEM majors could be developed by using data from Historically Black Colleges and Universities (HBCU), Hispanic Serving Institutions (HSI) or female only colleges. Research suggests that personality develops, in part, because of the influence of social and cultural mechanisms on the values, beliefs and actions of individuals (John, Robins & Pervin, 2008). Further study into possible differing presentations of personality type by gender or race could help further illuminate current understanding of the various predictors known to impact student enrollment in STEM.

One very important consideration in recommending further research in this area is the need to utilize a survey instrument designed specifically to evaluate personality type. Holland's (1997) theory was the foundation for the Strong Interest Inventory (SII), which is widely used in college and university counseling departments as a means of helping students determine their best career choice (Nauta, 2010). The ability to access and evaluate results from student responses to this type of personality scale, combined with data from the same college or university providing information on gender, race, major, or SES would vastly increase understanding of how this predictor affects student selection of major.

While the primary interest of this study was on student self-selection into STEM majors, another equally important issue is what variables affect a students' decision to stay the course and actually graduate in the major chosen? Research indicates that almost 70% of Whites, and 58% of Asians do not graduate with the STEM major initially chosen, with other races showing an equally dismal graduation rate in these majors (HERI, 2010). Additional longitudinal studies on the role of personality in impacting student persistence with major would be an important contribution to current research in the area of student retention and attrition in higher education.

Results of this study support the idea that knowledge of personality type can help predict the likelihood of a student self-selecting into a STEM major. Findings from the study in general corroborate other work showing that gender and race are also strong predictors of student enrollment in STEM. Although the study did not strengthen the legitimacy of using Holland's (1997) theory as a foundation for research on personality and self-selection into STEM, it did expand on our understanding on the role of personality by providing information on how combined personality type impacts student choice of major, and how personality impacts the selection of a specific type of STEM major. Linking personality type to student selection of college major provides educator and counselors additional framework for improving the student choice of, and continuation with, the major chosen.

APPENDIX

FACTOR LOADINGS FOR EXPLORATORY ANALYSIS WITH VARIMAX ROTATION FOR ITEMS ON FOUR PERSONALITY SCALES

Item	Factor Loading
Factor 1: Artistic Personality Scale (Cronbach's a = .75)	
1. Self-rating: artistic ability	.78
2. Self-rating: creativity	.72
3. Goal: writing original works (poems, short stories, novels, etc.	.64
4. Goal: creating artistic works (painting, sculpture, decorating, etc.)	.78
5. Goal: becoming accomplished in one of the performing arts (acting, dancing, etc.)	.60
Factor 2: Enterprising Personality Scale (Cronbach's a = .73)	
1. Self-rating: drive to achieve	.50
2. Self-rating: public speaking ability	.77
3. Self-rating: self-confidence (social)	.69
4. Self-rating: leadership ability	.77
5. Diversity rating: ability to discuss and negotiate controversial issues	.56
6. Habits of the mind: take a risk because you feel you have more to gain	.44
7. Goal: becoming a community leader	.47
Factor 3: Social Personality Scale (Cronbach's a = .80)	
1. Goal: influencing social values	.62
2. Goal: helping others who are in difficulty	.60
3. Goal: becoming involved in programs to clean up the environment	.73
4. Goal: helping to promote racial understanding	.75
5. Goal: adopting "green" practices to protect the environment	.74
6. Future act: participate in volunteer or community service work	.52
7. Diversity rating: ability to work cooperatively with diverse people	.41
8. Goal: improving my understanding of other countries and cultures	.74
Factor 4: Investigative Personality Scale (Cronbach's a = .71)	
1. Habits of the mind: support your opinions with a logical argument	.60
2. Habits of the mind: seek solutions to problems and explain them to others	.66
3. Habits of the mind: evaluate the quality or reliability of information you receive	.63
4. Habits of the mind: seek alternative solutions to a problem	.61
5. Habits of the mind: look up scientific research articles and resources	.57
6. Habits of the mind: explore topics on your own, even though it was not required for a class	.64
7. Habits of the mind: accept mistakes as part of the learning process	.40
8. Habits of the mind: revised you papers to improve your writing	.48

REFERENCES

Alfred, R., Shults, C., Jaquette, O., and Strickland, S. (2009). Portrait of a changing landscape. *Community colleges on the horizon: Challenge, choice or abundance* (pp 33-72*).* Lanham, Maryland: Rowman and Littlefied Education.

Allen, Jand Robbins, S. B. (2010). Effects of interest-major congruence, motivation, and academic performance on timely degree attainment. *Journal of Counseling Psychology, 57*(1), 23-35.

ACT (2012). *Assessing academic growth for college and career readiness.* Retrieved from http://www. act. org/aap.

Allen, Jand Robbins, S. B. (2008). Prediction of college major persistence based on vocational interests, academic preparation, and first-year academic performance. *Research on Higher Education, 49*, 62-79.

Astin, A. W., Oseguera, L., Sax, L. J., & Korn, W. S. (2002). *The American freshman: Thirty-five year trends.* Los Angeles, CA: Higher Education Research Institute, UCLA.

Avdeyeva, T. Vand Church, A. T. (2005). The cross-cultural generalizability of personality types: A Philippine study. *European Journal of Personality, 19*, 475-499.

Balgopal, R., McLean, J. E., and Kaufman, A. (1994). *The relationship among intelligence, personality, and vocational interests.* Paper session presented at the 1994 annual meeting of the Mid-South Educational Research Association, Nashville, TN.

Barrick, M. R., Mount, M. Kand Gupta, R. (2003). Meta-analysis of the relationship between the five-factor model of personality and Holland's occupational types. *Personnel Psychology, 56*, 45-74.

Bill & Melinda Gates Foundation (2011). *U.S. education.* Retrieved from http://gatesfoundation. org/pages/united-states/education-strategy. aspx.

Briggs, S. (2006). An exploratory study of the factors influencing undergraduate student choice: The case of higher education in Scotland. *Studies in Higher Education, 31*(6), 705-722.

Burrelli, Jand Rapoport, A. (2009). *Reasons for international changes in the ratio of natural science and engineering degrees to the college-age populations.* National Science Foundation InfoBrief. Retrieved from http://www. nsf. gov/statistics.

Campbell, P. B., Jolly, E., Hoey, L., and Perlman, L. K. (2002). *Upping the numbers: Using research-based decision making to increase diversity in the quantitative disciplines.* Report commissioned by the GE fund. Groton, MA: Campbell-Kibler Associates.

Chang, M. J., Sharkness, J., Newman, C. B. , & Hurtado, S. (2010). *What matters in college for retaining aspiring scientists and engineers.* Paper presented at the 2010 annual meeting of AERA, Denver, Colorado.

Chen, P. D. and Simpson, P. (2012). *Does personality matter? Applying Holland's typology to analyze students' self-Selection into science, technology, engineering, and mathematics majors.* Manuscript submitted for publication.

Chen, X. and Weko, T. (2009). *Stats in brief: Students who study science, technology, engineering and mathematics (STEM) in postsecondary education.* National Center for Education Statistics. Retrieved from www. ies. ed. gov

Christie, H., Munro, M., and Fisher, T. (2004). Leaving University early: exploring the differences between continuing and non-continuing students. *Studies in Higher Education, 29*(5), 617-636.

Church, A. T., Katigbak, M. S., Miramontes, L. G., DelPrado, A. M., and Cabrera, H. F. (2007). Culture and the behavioural manifestations of traits: An application of the Act Frequency approach. *European Journal of Personality, 21,* 389-417.

Clack, G. Band Head, J. O. (1999). Gender differences in medical graduates' assessment of their personal attributes. *Medical Education, 33*(2), 101-105.

Cole, D& Espinoza, A. (2008). Examining the academic success of Latino students in science, technology, engineering and mathematics (STEM) majors. *Journal of College Student Development, 49*(4), 285-300.

Commission on Professionals in Science and Technology. (2010). *New study finds graduation gap among STEM majors.* Retrieved from http://www. cpst. org/hrdata/documents/pwm13s/C472E042. pdf

Crisp, G., Nora, A., and Taggart, A. (2009). Student characteristics, pre-college, college, and environmental factors as predictors of majoring in and earning a STEM degree: An analysis of students attending a Hispanic serving institution. *American Educational Research Journal, 46,* 4, 924-942.

DeCoster, J. (1998). *Overview of factor analysis.* Retrieved from http://www. stat-help. com/notes. html.

Daempfle, P. A. (2003-2004). An analysis of the high attrition rates among first year college science, math and engineering majors. *Journal of College Student Retention: Research, Theory, Practice, 5*(1), 37-52.

DeFruyt, Fand Mervielde, I. (1996). Personality and interests as predictors of educational streaming and achievement. *European Journal of Personality, 10,* 405-425.

Donnellan, M. Band Lucas, R. E. (2008). Age difference in the big five across the life span: Evidence from two national samples. *Psychology and Aging, 23*(3), 558-566.

Eagan,M. K., Hurtado, S., & Chang, M. J. (2010). *What matters in STEM: Institutional contexts that influence STEM bachelor's degree completion rates.* Paper presented at the 2010 annual meeting of ASHE, Indianapolis, IN.

Feldman, K. A., Ethington, C. A. and Smart, J. C. (2001). A further investigation of major field and person-environment fit: sociological versus psychological interpretations of Holland's theory. *Journal of Higher Education, 72*(6), 670-698.

Feldman, K. A., Smart, J. C. , and Ethington, C. A.(1999). Major field and person-environment fit: Using Holland's theory to study change and stability of college students. *Journal of Higher Education, 70*(6), 642-669.

Feldman, K. A., Smart, J. C. and Ethington, C. A. (September/October, 2004). What do college students have to lose? Exploring the outcomes of differences in person-environment fits. *Journal of Higher Education, 75*(5), 528-555.

Field, A. (2009, 3rd Ed.). *Discovering statistics using SPSS.* London, EC1Y: SAGE Publications, Ltd.

Garson, D. G. (2010). Quantitative research in public administration. *Logistic regression.* Retrieved from http://faculty. chass. ncsu. edu/garson/PA765/logistic. htm

George, Y. S., Neale, D. S., Van Horne, V., and Malcom, S. M. (December, 2001*). In pursuit of a diverse science, technology, engineering, and mathematics workforce: Recommended research priorities to enhance participation by underrepresented minorities.* Washington, DC: American Association for the Advancement of Science.

Grandy, J. (1998). Persistence in science of high-ability minority students. Research report for the national science foundation. *Journal of Higher Education, 69*(6), 589-620.

Grossman, C. R. (2008). *Preparing WIA youth for the STEM workforce.* LearningWork Connections. Youthwork Information Brief. Retrieved from www. learningworkconnection. org.

Hair, J. F., Jr., Black, WC., Babin, B. J., & Anderson, R. E.(2010, 7th Ed.). Logistic regression: Regression with a Binary Dependent Variable. *Multivariate Data Analysis* (pp. 317-344). Upper Saddle, NJ: Prentice Hall Publications.

Higher Education Research Institute (2010). *New study finds graduation gap among STEM majors.* Retrieved from

http://www. cpst.org/hrdata/documents/pwm13s/C472E042. pdf

Holland, J.L. (1997, 3rd Ed.). *Making vocational choices: A theory of vocational personalities & work environments.* Odessa, Florida: Psychological Assessment Resources, Inc.

Hurtado, S., Inkelas, K. K., Briggs, C. , Rhee, B.(1997). Differences in college access and choice among racial/ethnic groups: Identifying continuing barriers. *Research in Higher Education, 38*(1), 43-75.

John, O. P., Robins, R. W., and Pervin, L. A. (eds)(2008). *Handbook of personality: Theory and research.* New York, New York: The Guilford Press.

Komarraju, Mand Karau, S. J. (2005). The relationship between the big five personality traits and academic motivation. *Personality and Individual Differences, 39,* 557-567.

Labov, J. B., Singer, S. R., George, M., Schweingruber, H. A., Hilton, M. L. (2009). Effective practices in undergraduate STEM education part I: Examining the evidence. *Life Sciences Education, 8,*157-161.

Larson, L. M., Wu, T. F., Bailey, D. C., Gasser, C. E., Bonitz, V. S. and Borgen, F. H.(2010). The role of personality in the selection of a major: With and without vocational self-efficacy and interests. *Journal of Vocational Behavior,76*, 211-222.

Lounsbury, J. W., Saudargas, R. A., Gibson, L. W., and Leong, F. T.(2005). An investigation of broad and narrow personality traits in relation to general and domain-specific life satisfaction of college students. *Research in Higher Education, 46*(6), 707-729.

National Academies (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future.* The National Academies Press, Washington, DC. Retrieved from http://www. nap. edu/catalog

National Center for Education Statistics (2000). *Classification of instructional programs 2000 edition.* Retrieved from http://nces. ed. gov/pubs2002/cip2000/index. asp

National Science and Technology Council Committee on Science (2006). *Review and appraisal of the federal investment in STEM education research.* NSTC Education and Workforce Subcommittee.

National Science Foundation (2003). *The global and domestic contexts: Global competitions for the science and engineering workforce.* The Science and Engineering Workforce: Realizing America's Potential (pp. 22-28). Retrieved from http://www. nsf. gov/nsb/documents/2003/nsb0369/nsb0369. pdf

National Science Board (2010). *Preparing the next generation of STEM innovators: Identifying and developing our nation's human capital.* Retrieved from www. nsf. gov/nsb/stem.

Nauta, M. M. (2010). The development, evolution, and status of Holland's theory of vocational personalities: Reflections and future directions for counseling psychology. *Journal of Counseling Psychology, 57,*1,11-22.

Newton, R. R. and Rudestan, K. E. (1999). How do I deal with missing values? *Your statistical consultant: Answers to your data analysis questions* (pp. 156-163). Thousand Oaks, CA: Sage Publications.

Oseguera, L& Rhee, B. S. (2009). The influence of institutional retention climates on student persistence to degree completion: A multilevel approach. *Research in Higher Education, 50*, 546-569.

Pacheco, E.(May, 2010). *Sloan consortium teams up with HP on "HP catalyst initiative" to explore the future of science, technology, engineering and mathematics education.* Retrieved from http://sloanconsortium. org/news_press/hp-catalyst

Pallant, J.(2007). *SPSS survival manual.* New York, New York: McGraw-Hill Open University Press.

Pew Research Center (2011). *Is college worth it?* Retrieved from http://pewresearch. org/pubs/1993/survey-is-college-degree-worth-cost-debt-college-presidents-higher-education-system.

Pike, G. R.(2006). Vocational preferences and college expectations: An extension of Holland's principle of self-selection. *Research in Higher Education, 47, 5,* 591-612.

Pike, G. R. (2006). Students' personality types, intended majors, and college expectations: Further evidence concerning psychological and sociological interpretations of Holland's theory. *Research in Higher Education, 47,* 7, 801-822.

Porter, S. R. and Umbach, P. D.(2006). College major choice: An analysis of person-environment fit. *Research in Higher Education, 47*(4), 429-449.

Pryor, J. H., Hurtado, S., DeAngelo, L., Sharkness, J., Romero, L. C., Korn, W. S., and Tran, S.(2009). *The American freshman: National norms for fall 2008.* Los Angeles, CA: Higher Education Institute, UCLA.

Pulkkinen, L.(1996). Female and male personality styles: A typological and developmental analysis. *Journal of Personality and Social Psychology, 70*(6), 1288-1306.

Russell, A.(2005). Policy matters: Strengthening the science and mathematics pipeline for a better America. *American Association of State Colleges and Universities, 2,* (11).

Schmitt, D. P., Realo, A., Voracek, M., Allik, J.(2008). Why can't a man be more like a woman? Sex differences in big five personality traits across 55 cultures. *Journal of Personality and Social Psychology, 94*(1), 168-182

Shernoff, D. J. and Hoogstra, L.(2001). Continuing motivation beyond the high school classroom. *New Directions for Child and Adolescent Development, 93*, 73-87.

Simpson, J.(2001). Segregated by subject: Racial differences in the factors influencing academic major between European Americans, Asian Americans, and African, Hispanic and Native Americans. *Journal of Higher Education, 72*(1), 63-100.

Smith, E.(2008). *Using secondary data in educational and social research.* New York, New York: McGraw-Hill Open University Press.

SPSS (2007). SPSS Missing value analysis 16. 0. retrieved from [www. hanken. fi/student/media/3618/spssbaseusersguide160. pdf](www.hanken.fi/student/media/3618/spssbaseusersguide160.pdf).

Subotnik, R. F., Edmiston, A. M. and Rayhack, K. M.(2007). Developing national policies in STEM talent development: Obstacle and opportunities. In *Science Education: models and networking of student research training under 21*Washington, DC: American Psychological Association.

Subotnik, R. F., Tai, R. H., Rickoff, R., and Almarode, J.(2010). Specialized public high schools of science, mathematics, and technology and the STEM pipeline: What do we know now and what will we know in 5 years? *Roeper Review, 32,* 7-16.

Sweet, S. A. and Grace-Martin, K.(2002, 2nd Ed.). Multivariate analysis with logistic regression. *Data analysis with SPSS: A first course in applied statistics* (pp. 157-166). Boston, MA: Allyn & Bacon.

Tan, D.L.(2002). *Majors in science, technology, engineering and mathematics: Gender and ethnic differences in persistence and graduation.* Paper presented at the 42nd annual association for institutional research forum, Toronto, Canada, 2002.

Thebaud, S.(2010). Gender and entrepreneurship as a career choice: Do self-assessments of ability matter? *Social Psychology Quarterly,73*(3), 288-304.

Thompson, W. and Hickey, J. (2005). *Society in focus.* Boston, MA: Pearson, Allyn & Bacon.

Tinsley, H. E. A.(2000). The congruence myth: An analysis of the efficacy of the person-environment fit model. *Journal of Vocational Behavior, 56,* 147-179.

Tinto, V.(1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research, 45*(1), 89-125.

Tracey, T. J. G.(2007). Moderators of the interest congruence-occupational outcome relation. *International Journal of Vocational Guidance, 7,* 37-45.

Trapmann, S., Hell, B., Hirn, J. O. W. , and Schuler, H.(2007). Meta-analysis of the relationship between the big five and academic success at university. *Journal of Psychology, 215*(2), 132-151.

Triandis, H. C. and Eunkook, M. S. (2002). Cultural influences on personality. *Annual Review of Psychology, 53,* 133-60.

Tyson, W., Lee, R., Borman, K. M. and Hanson, M. A.(2007). Science, technology, engineering, and mathematics (STEM) pathways: High school science and math coursework and postsecondary degree attainment. *Journal of Education for Students Placed at Risk, 12*(3), 243-270.

United States Census Bureau (2011). *Population profile of the United States.* Retrieved from http://www. census. gov/population/www/pop-profile/natproj. html

van Langen, A. , and Dekkers, H.(2005). Cross-national differences in participating in tertiary science, technology, engineering and mathematics education. *Comparative Education, 41(*3), 329-350

Vogt, P. W.(2007). *Quantitative research methods for professionals.* Boston, MA: Pearson Education, Inc.

Watson, G., Cavallaro, J., & Austin, H.(2004). Exploring relatedness to field of study as an indicator of student retention. *Higher Education Research & Development, 23*(1), 57-72.

Willcoxson, L. and Wynder, M.(2010). The relationship between choice of major and career, experience of university and attrition. *Australian Journal of Education, 54*(2), 175-189.