Deciding on Science: An Analysis of Higher Education Science Student Major Choice Criteria

by

Stephen Wilson White

September 2014

A Dissertation submitted to the Education Faculty of Lindenwood University in

partial fulfillment of the requirements for the degree of

Doctor of Education

School of Education

Declaration of Originality

I do hereby declare and attest to the fact that this is an original study based solely upon my own scholarly work at Lindenwood University and that I have not submitted it for any other college or university course or degree.

Full Legal Name: Stephen Wilson White

Signature: Stephen W. White Date: 11/24/14

Acknowledgements

I would like to thank my committee members, Dr. Sherry DeVore, Dr. Rhonda Bishop, and Dr. Steven Bishop for their guidance and support. Their advice and encouragement was vital to the completion of this research. I express my sincerest gratitude to the faculty and staff of the biology departments of the schools participating in this research for their help recruiting participants. Finally, I would like to acknowledge the unwavering support and encouragement of my wife, Jennifer White.

Abstract

The number of college students choosing to major in science, technology, engineering, and math (STEM) in the United States affects the size and quality of the American workforce (Winters, 2009). The number of graduates in these academic fields has been on the decline in the United States since the 1960s, which, according to Lips and McNeil (2009), has resulted in a diminished ability of the United States to compete in science and engineering on the world stage. The purpose of this research was to learn why students chose a STEM major and determine what decision criteria influenced this decision. According to Ajzen's (1991) theory of planned behavior (TPB), the key components of decision-making can be quantified and used as predictors of behavior. In this study the STEM majors' decision criteria were compared between different institution types (two-year, public four-year, and private four-year), and between demographic groups (age and sex). Career, grade, intrinsic, self-efficacy, and self-determination were reported as motivational factors by a majority of science majors participating in this study. Few students reported being influenced by friends and family when deciding to major in science. Science students overwhelmingly attributed the desire to solve meaningful problems as central to their decision to major in science. A majority of students surveyed credited a teacher for influencing their desire to pursue science as a college major. This new information about the motivational construct of the studied group of science majors can be applied to the previously stated problem of not enough STEM majors in the American higher education system to provide workers required to fill the demand of a globally STEM-competitive United States (National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2010)

Table of Contents

Chapter One: Introduction

In 1957, the Soviet Union launched a tiny satellite named Sputnik into orbit around the Earth and surpassed the United States in the race to space (Peoples, 2008). In response to this event, the National Defense Education Act (NDEA) was passed in 1958 providing funding for improvement of American science and math education (Drew, 2011). Since that time, numerous science curriculum reform efforts have been launched (Bybee & McInerney, 1995). In the 1960s, *new math* focused on elementary schools' reform of mathematics education (Bybee & McInerney, 1995). In the 1980s, the National Science Foundation distributed grants focused on middle schools, and in the 1990s, the American Association for the Advancement of Science (AAAS) created benchmarks for scientific literacy (Bybee & McInerney, 1995). Summarizing this 30-year timeline, Bybee and McInerney (1995) commented:

> By early 1990's, more than 300 reports admonished those within the educational system to reform science education. Depending on the group publishing the report, the recommendations for education programs emphasized issues, such as updated scientific and technologic knowledge, application of contemporary learning theory and teaching strategies, improved approaches to achieve equity, and better preparation of citizens for the workplace. (p. 1)

Today, efforts to improve and expand America's scientific competencies continue in the form of a comprehensive approach that reaches into the combined areas of science, technology, engineering, and math, which are now commonly referred to using the collective acronym STEM. In 2006, the American Competitiveness Initiative was created to improve America's global economic competitiveness by increasing funding for

STEM education areas (Kuenzi, 2008). That same year, the United States National Academies announced actions which should be taken by government to increase the United States' competitiveness in the 21st century (President's Council of Advisors on Science and Technolgy, 2011). One of those recommended actions was to enlarge the population of students prepared to enter college and graduate with STEM degrees (Ewell, Jones, & Kelly, 2003).

The number of college students choosing to major in science, technology, engineering, and math in the United States affects the size and quality of the American workforce (Winters, 2009). The number of graduates in these academic fields has been declining in the United States since the 1960s, which, according to Lips and McNeil (2009), has resulted in a diminished ability for the United States to maintain competitiveness in science and engineering on the world stage. Currently, there is a focused national effort to increase the number and quality of STEM graduates in the United States (National Economic Council [NEC], Council of Economic Advisers [CEA], & Office of Science and Technology Policy [OSTP], 2011). Several studies focused on increasing the educational quality in STEM fields have been conducted, which primarily examined classroom methods and curricular content in the areas of STEM (Bryce, 2010; Gentile et al., 2010; Jenkins, 2011). While these studies were designed to explore aspects of these programs, they did not specifically address mechanisms for increasing the numbers of students choosing to major in STEM education.

The choice students make when choosing a college major will impact their development while they are in college and affect their job prospects after graduation

(United States Bureau of Labor and Statistics, 2014). While this is an important decision, research has shown many students are tentative and uncertain about the academic planning decisions they have made (Titley & Titley, 1980). Studies have demonstrated students use factors, such as aptitude, interest, and job availability while deciding on their college major (Kalevitch et al., 2012; Malgwi, Howe, & Burnaby, 2005; Tan & Laswad, 2009). However, these studies have not specifically addressed student decision making processes as they relate to STEM major selection.

David Drew (2011), who wrote, *Stem the Tide: Reforming Science, Technology, Engineering and Math Education in America,* posited solving the STEM education participation problem will require looking for students in new places. Drew (2011) explained many potential students are discouraged from participating in STEM academic fields due to poor self-concept, which has been cultivated by teachers and society as a whole. Drew (2011) concluded, “millions of people are erroneously discouraged from studying mathematics and science because of false assumptions about who has the ability to master these subjects” (p. 4). The data provided by this research added to the current body of knowledge by exploring science students’ self-concept that could lead to strategies focused on increasing the number of students entering STEM majors.

Background of the Study

In 2010, the United States produced less than 15% of all STEM students worldwide, down from 50% in 1960 (Hong & Shull, 2010). The United States currently ranks 21st in ninth grade science literacy, with Finland, Hong-Kong, Japan, New Zealand, Canada, Estonia, Australia, Netherlands, and Taiwan take the top ten spots (Program for International Student Assessment*,* 2011). Atkinson and Mayo (2010) stated "the United States is consistently not able to produce enough of its own STEM workers in key fields" (p. 6). According to the survey findings, STEM students often cited poor teaching and the lack of supportive faculty as reasons for not continuing their chosen field of study (Hong & Shull, 2010). To improve education in STEM fields, educators must focus on both preparation and inspiration of students (President's Council of Advisors on Science and Technology, 2012).

Hong and Shull (2010) further noted faculty can often be perceived by students as either a significant source of support or the root of their frustrations. Frustrations may lead to low retention rates among STEM majors. The role faculty play in student learning, motivation, and retention cannot be over-emphasized. Students make a decision regarding their major subject choice during the first class they take in that subject area (Malgwi, Howe, & Burnaby, 2005). The data from this study should lead researchers to question whether introductory STEM courses may deter prospective majors due to their breadth, rigor, and instruction style.

Conceptual Framework

The conceptual framework of this study utilized the theory of planned behavior (TPB) as its guide. According to Ajzen (1991), the TPB identifies three major constructs of behavior: attitudes, subjective norm, and perceived behavioral control. The choice the student makes is the end result of a series of factors employed by the student to reach a decision (Ajzen, 1991). Rational decision-making follows a path or process from problem to solution. Tan and Laswad (2009) applied the TPB developed by Ajzen (1991) to student choice of academic major. Tan and Laswad (2009) concluded:

> Generating student interest in a subject area during their first year is also an important determinant as it has an impact on change of major. Stimulating students' interest in accounting starting from their first year of study may perhaps sway them to consider accounting as their major. (p. 251)

Science majors all share a common behavior, namely, deciding to major in science. However, the degree to which science majors use each of the three TPB constructs is unknown (Ajzen, 1991). Identifying the decision-making criteria most commonly used within this science major population and the various combinations of criteria used to arrive at the conclusion to major in science is needed.

By applying constructs of TPB, the possibility exists to learn their impact on students declaring science their major (Tan & Laswad, 2009). Studying student characteristics may provide the information necessary to grow the science major population. Increasing the number of science majors would increase the pool from which more graduates could emerge. The results of this study would be used to cultivate those characteristics in students who have not yet declared a major, or are undecided in their major choice.

Ajzen (1991) found the three components of the TPB can be good predictors of behavior, as intentions are a construct of attitudes, subjective norm, and perceived behavior control. Ajzen (1991) emphasized. "It is no longer very meaningful to ask whether attitudes and personality traits predict behavior – they clearly do" (p. 143). If the dimensions and depth of each of the TPB constructs can be identified within the science major population, then it is possible subpopulations, such as science majors at different institution types, could be compared and analyzed for differences between predominant motivational types and sources of motivation. The path leading a student to pursue a science major may be different for students attending community college when compared to students attending a four-year institution or students attending private institutions. Knowing these components of decision-making for each institution type could lead to more effective institution-specific targeting efforts for increased science participation.

Statement of the Problem

Atkinson and Mayo (2010) pointed out the United States is consistently not able to produce enough of its own STEM workers in key fields. Employment in STEM fields was recognized in 2007 as being important to the United States' economic growth and competitiveness (United States Department of Labor [DOL], 2007). That same year, the STEM Workforce Challenge Report summarized the problem by stating: "American pre-eminence in STEM will not be secured or extended without concerted effort and investment" (DOL, 2007, p. 1). The National Science Foundation report, *Preparing the Next Generation of STEM Innovators: Identifying and Developing Our Nation's Capital*, articulated that scientific and technological innovations have become increasingly important in the 21st century as the United States pursues the challenge and reward of a knowledge-based economy (National Science Board [NSB], 2010). Success in this evolving information-based, technologically advanced society will require students to enhance their capabilities in STEM areas beyond what was, in the past, considered acceptable (NSB, 2012).

A report by the National Economic Council, the Council of Economic Advisers, and the Office of Science and Technology Policy (NEC, CEA, & OSTP, 2011) predicted America's future economic growth and competitiveness largely depends on skills developed in STEM educational fields. The report called for improvement in the results of American science education (NEC, CEA, & OSTP, 2011). In order to improve STEM education, educators in the United States must focus on both preparation and inspiration (President's Council of Advisors on Science and Technology, 2012).

As stated previously, since the 1960s, American leaders have been reiterating the importance of having a larger, stronger STEM trained workforce (Atkinson & Mayo, 2010; DOL, 2007; National Economic Council et al., 2011; NSB, 2012). The reasons for this focus on STEM have ranged from national defense, to the economic importance of global competition, and most recently to encourage industry innovations in sustainable energy (National Economic Council et al., 2011).

Building a STEM workforce requires a STEM education pipeline which starts with students deciding to major in a STEM field (Carnevale, Smith, & Melton, 2011). Students make college major choice decisions based in part on experiences they have with faculty representing STEM teaching areas (Hong & Shull, 2010). Hong and Shull (2010) summarized faculty can often be perceived by students as significant sources of support, or the root of their frustrations, and was one of the factors students attributed as a reason for not continuing in their chosen major. The degree to which science majors base their decisions on other factors is not well-represented in the literature (Hong & Shull, 2010). Tan and Laswad (2009) only examined the decision-making processes of accounting majors and categorized those decisions into three categories based on the TPB (Ajzen, 1991).

Purpose of the Study

The purpose of this research study was to learn why students choose a STEM major and to determine what decision criteria influenced this decision. According to Ajzen's (1991) TPB, the key components of decision-making can be quantified and used as predictors of behavior. The STEM majors' decision criteria were compared between different institution types (two-year, four-year, and private four-year), and between demographic groups (age and sex.) Analysis of this research provides insight into the decision-making process students employ as it relates to the selection of an academic major in a STEM field. While the TPB has been used to study student major choice, it has not been used to specifically study STEM related areas. Knowing, understanding, and addressing TPB factors could possibly lead to a change in how instructors approach students. which, in turn, could impact the number of students declaring a STEM area academic major in the United States.

The quality of education is the focus of most of the STEM improvement efforts (Ewell et al., 2003). While these efforts focus on improving existing curriculum and pedagogy, more attention could be focused on increasing the number of students entering STEM majors (Ewell et al., 2003). Students entering STEM majors in higher numbers could have a far greater impact on the STEM workforce than educational efficiency and quality efforts alone (Bretell & Ault, 2010).

Research questions. This research proposed to provide answers to the following questions:

1. What motivation factors are most likely to be reported by students in pursuit of a STEM major?

2. What differences exist, if any, in the types of motivation factors reported by STEM students as disaggregated by the types of higher education institutions they attend?
3. What differences exist, if any, in the types of motivation factors reported by STEM students as disaggregated by age and sex?

Definitions of Key Terms

The following terms were provided:

Higher education. A term identified by Ewell et al. (2003) in relation to the STEM pipeline as a transition from high school, identifying dual credit and open enrollment two-year institutions as critical steps.

Integrated STEM. Linking STEM concepts together in education rather than separating concepts into traditional subject areas (Gallant, 2010).

Mentoring. Budny, Paul, and Newborg (2010) defined mentoring specific to STEM improvement as providing support to students during academic transitions, thereby aiding student retention.

Pedagogy. Atkinson and Mayo (2010) identified pedagogy as the needed area of focus for STEM improvement. Atkinson and Mayo (2010) specifically emphasized project-based pedagogy as an improvement to traditional lecture-based pedagogy.

Pipeline. A term used in education to describe the process by which students enter education, how they are educated, and the degree or employment attained and is conceptually outlined by Ewell et al. (2003).

STEM. An acronym for science, technology, engineering, and math educational subject areas identified by the National Science Board (2010) for improvement to achieve a competitive American workforce.

Theory of Planned Behavior (TPB). Ajzen's (1991) theory suggests decision-making is a result of a person's attitudes, subjective norms, and perceived behavioral control.

Workforce. Summarized by Metcalf (2010) as the conceptual end result of the STEM pipeline.

Limitations and Assumptions

The following limitations and assumptions were identified in this study:

Sample demographics. Study participants were declared science majors at two-year, four-year, and private four-year institutions in southwest Missouri. The participants represented the economic and social environment of a limited geographic area. The participants were identified because they were enrolled in courses as a part of a biology degree program offered by the participating institution. It was assumed the population was only representative of the aforementioned geographic area and the associated diversity, economic, and social constructs.

Instrument. The questionnaire was a limitation due to wording and phrasing considerations which could have varying effects on study participants. Every effort was made to ensure the wording and phrasing of the survey questions would not influence the free response of the study participants.

Summary

STEM employment fields require a specifically trained, highly skilled and creative workforce (President's Council of Advisors on Science and Technolgy, 2011).

The educational system in the United States produces this workforce, but analysis shows an improvement and expansion of the STEM workforce is needed in the United States to supply the growing demand (DOL, 2007). Modern global competition in STEM employment fields has fueled the pressure for a greater American participation in scientific innovation and technological advances (Atkinson & Mayo, 2010). As a result, higher education in STEM areas is increasingly the focus for improvement (Lloyd & Eckhardt, 2010). Higher education, as a whole, needs to produce more STEM graduates better prepared to compete globally for American STEM preeminence (President's Council of Advisors on Science and Technology, 2012).

This research was designed to focus on the decision-making processes students employ when deciding on STEM academic majors. Understanding the reasons why students choose to major in a STEM field could be instrumental in providing the insight needed to cultivate a larger participation in these educational areas. A reasonable result of increased participation in STEM education would be an increase in the number of graduates available to fill United States STEM jobs.

In Chapter Two, a brief history of the United States' STEM efforts is described followed by descriptions of the areas of focus for STEM improvement. Student recruitment and retention are explored by examining mentorship, faculty engagement, and the development of new students. Educational pedagogies in STEM are identified and compared in Chapter Two. Finally, Chapter Two relates the educational pipeline, higher education attainment, and immigration to the STEM workforce in America.

Chapter Two: Review of Literature

As a world leader, the United States has an interest in competing in the realm of world-wide innovation (DOL, 2007). Areas currently considered pertinent to this innovation are those of science, technology, engineering, and math (STEM) occupational fields (Atkinson & Mayo, 2010). Leading innovation in STEM areas has been on the United States' agenda since the 1960s when Russia won the race to space with the success of the Sputnik satellite (Peoples, 2008). Hindsight apparently revealed the United States had not devoted enough educational resources aimed at developing America's youth in the academic STEM areas (Peoples, 2008).

According to Toulmin and Groome (2007), in order to combat developing national security implications, and to bolster identified deficiencies in the education system, government agencies, businesses, and private groups put forth reports and initiatives aimed at increasing American student participation in STEM educational areas. By focusing on factors contributing to national educational excellence in the STEM fields, the United States can at least retain, and at most improve, its world rank in innovation, global competitiveness and national security (DOL, 2007).

The number of students choosing a college major in STEM affects the size and quality of the workforce in the United States (Winters, 2009). The number of graduates in these academic fields has been on the decline in the United States since the 1960s, which, according to Lips and McNeil (2009), results in the United States possessing a diminished ability to compete in science and engineering on the world stage. Improving STEM education requires educators to focus on both the preparation and inspiration of students (President's Council of Advisors on Science and Technology, 2012). Placing emphasis on encouraging students through innovative teaching and engaging content could impact student retention, especially in introductory STEM coursework (Atkinson & Mayo, 2010). Currently, there is a focused national effort to increase the number and quality of STEM graduates in the United States (NEC et al., 2011). Several studies, focused on increasing educational quality in STEM areas, have been conducted which primarily examine classroom methods and curricular content in the areas of STEM (Bryce, 2010; Gentile, et al., 2010; Jenkins, 2011). While these educational pedagogies were designed to explore educational effectiveness, they did not specifically address a mechanism for recruiting and increasing the numbers of students choosing to major in STEM education.

A review of the literature pertaining to STEM revealed three major areas of current research emphasis and will be discussed in detail under the following headings: recruitment and retention, educational pedagogies, and workforce requirements. In the areas of recruitment and retention, the role faculty play in student retention and an overview of faculty characteristics that may improve student success in STEM fields are explored. In the STEM educational pedagogies section of this chapter, STEM educational pedagogies will be reviewed highlighting integrated and non-integrated STEM educational ideologies. In the third and final segment, STEM workforce requirements, the educational pipeline leading to employment, emphasizing workforce demands and the need for higher education attainment, are examined.

Recruitment and Retention

The decisions regarding a career students make when choosing a college major will impact their educational experience while they are in college and affect their job prospects after graduation (United States Bureau of Labor and Statistics, 2014). While this is an important decision, research has shown many students are tentative and uncertain about the academic planning decisions they have made (Titley & Titley, 1980). A variety of factors are considered by students when deciding on their academic major (Tan & Laswad, 2009). Porter and Umbach (2006) found students of the same major usually share common political views and personality traits. Whether these views and traits were developed after the student's major choice, or were present prior to the major choice was not studied. However, Porter and Umbach (2006) posited uniformity of personality types and political views within major groups could be the result of a coalescing of the ideas and attitudes within a group over time, or a result of non-conforming students who dropped out or changed their major.

Bretrell and Ault (2010) have observed popular culture to be an influence on student major choice when they noticed a correlation between student decisions and careers often depicted in popular motion pictures and television programs. The conclusion could be made that with the benefit of career counseling, a student may choose a college major through a more informed process (Bretell & Ault, 2010). Bretell and Ault (2010) further clarified, "In the end, few students ever explore the hundreds of career options available to them. Instead, many choose from the few careers with which they are familiar or from information they glean from movies, television, or other media" (p. 5). Bretell and Ault (2010) also found students frequently state they would be more likely to continue with their college education if they were more informed and confident about their major choice. Faculty focusing on content specific problem solving in introductory level coursework may help students develop links between their education and the applicability of their education to future employment requirements (Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012).

Students may be predisposed to choose a particular major based on their own unique qualities (Bretell & Ault, 2010; Titley & Titley, 1980). Tan and Laswad (2009) found students' perceptions of their own skills, aptitude, interest, and job availability were important factors when deciding on a college major. While some students may rely on advice of parents, teachers, and friends when deciding on a major (Tan & Laswad, 2009). A classroom experience designed to instill confidence in students may contribute to an eventual increase in retention among students in STEM educational areas (Carnevale et al., 2011).

Tan and Laswad (2009) noted there are several factors that play a role in some students' major choice decision and concluded a student's major choice is influenced by his or her own beliefs and attitudes; the influence of an important mentor; and by attentive, engaged teachers. The facilitative role faculty play in student learning and motivation in science cannot be over-emphasized. Solinas, Masia, Maida, and Muresu, (2012) summarized, "an important role is represented by the ability of the teacher to maintain the students' attention and to provide encouragement and advice" (p. 40).

Drew (2011) explained many potential students are discouraged from participating in STEM academic fields due to poor self-concept, which has been cultivated by teachers and society as a whole. Students' attitudes affecting their major choice decision are developed early in the students' college career, even during their first year (Tan & Laswad, 2009). Malgwi et al. (2005) found students make a decision regarding their major subject choice during the first class they take in that subject area.

Osborne, Simmons, and Collins (2003) described traditional introductory science courses as follows:

> The courses focused on problem-solving techniques, and lacked an intellectual overview of the subject; there were too many 'how much' questions, not enough discussion of 'how' or 'why;' pedagogy was condescending and patronizing, examinations were not challenging; there was no community or discussion and the atmosphere was competitive. Furthermore, they raise substantial questions about why the pedagogy of some science teachers is so unappealing to the majority of students, suggesting that, while science teachers may be knowledgeable about their subject, they are failing to achieve their primary task of establishing a range of varied learning opportunities and communicating their subject effectively. (p. 1068)

By examining the interaction between instructors and students in introductory science courses, it may be possible to improve student retention, while simultaneously improving subject matter delivery. Linking classroom activities to real-world, subject specific problems may prevent students withdrawing due to their questioning the applicability and usefulness of the information to which they are being exposed to in the educational environment (Gasiewski et al., 2012).

Instructors as mentors. The findings of Osborn et al. (2003) regarding student engagement highlight the important role effective teachers play in gauging student comprehension through a purposeful, planned teaching strategy to encourage and retain students. A balance must be reached when hiring teachers, between professional STEM know-how and the ability to inspire students to learn (National Research Council, 2007; President's Council of Advisors on Science and Technology, 2012).

Hong and Shull (2010) discovered students often cited poor teaching and the lack of supportive faculty as reasons for STEM students not continuing their chosen field of study, and further ascertained faculty can often be perceived by students as significant sources of support or sources of their frustrations, which in reality may lead to low retention rates among STEM majors. These findings should lead researchers to question whether introductory STEM courses may deter prospective majors due to their breadth, rigor, and instruction style. Drew (2011) concluded, "millions of people are erroneously discouraged from studying mathematics and science because of false assumptions about who has the ability to master these subjects" (p. 4).

Tobias (1990) identified the group of students that drop out of science coursework as the second tier. These students do not respond well to traditional science instruction methods and might otherwise have stayed in the science pipeline. Jane Fraser, an engineering professor who was cited in Tobias (1990), communicated her frustration in knowing many potential students are choosing not to pursue engineering because they are discouraged by the early courses in the sequence. Fraser further stated she never gets the chance to introduce those students the engaging real-world engineering subject matter (as cited in Tobias, 1990).

A change in introductory coursework could provide better insight and encouragement to students interested in professions in STEM fields. Students often choose their major early in their college career when they are taking introductory courses that have relatively high dropout rates. Introductory courses are often evaluated based on mastery of material not entirely indicative of the skills needed in the workplace (Drew, 2011; Malgwi et al., 2005; Osborne, Simon, & Collins, 2003; Tobias, 1990).

As previously stated, the choice a student makes when deciding on an academic major is the result of factors employed by the student to reach a decision (Drew, 2011; Tan & Laswad, 2009; Tobias, 1990). Tan and Laswad (2009) applied the TPB developed by Ajzen (1991) to student choice of academic major. Tan and Laswad (2009) also highlighted the importance of first-year coursework to students deciding on an academic major. Focusing specifically on stimulating student interest in early coursework can impact the choice of academic major by reducing the number of students choosing to change their major due to becoming disengaged during introductory courses (Tan & Laswad, 2009).

According to Ajzen (1991), the TPB identifies attitudes, subjective norms, and perceived behavioral control as the major constructs of behavior. Ajzen (1991) determined behavior can be predicted with considerable accuracy from intentions which are a construct of the three components of the TPB. Osborne et al. (2003) contended attitudes are a measure of a subject’s preferences and feelings about an object and are not necessarily related to behaviors.

Due to the large number of constructs making up an individual’s attitude, singling out attitude as a measurable, testable component of decision-making is problematic (Osborne et al., 2003). Attitudes can change frequently, especially among college freshmen (Budny, Paul, & Newborg, 2010). Osborne et al. (2003) emphasized the importance of recognizing the difference between attitudes towards science and attitudes towards school science. Osborne et al. (2003) validated Ajzen’s (1991) inclusion of subjective norms as important for science decisions, as support from peers can be a strong determinant of student choice. Tan and Laswad (2009) explained that subjective norms are an individual's perception of the social pressure he or she feels, and perceived behavioral control is a non-motivational construct to the extent that people are realistic about their ability to perform a task.

Students' attitudes towards science can be learned through the use of a survey designed to ascertain which decision-making behavior construct the student relies upon most heavily (Ajzen, 1991; Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011). Several authors have surveyed students to identify student characteristics and learning outcomes within the STEM fields of study. Adams et al. (2006) studied the impact of teaching styles on the likelihood of students becoming physics majors and differences in learning styles of male and female physics majors. The survey by Adams et al. (2006) provided data supporting the idea that classroom instruction specifically aimed at addressing students' beliefs in physics improved student retention.

McConnell et al. (2006) examined teaching and testing methods between major and non-major geosciences courses and found frequent testing of basic concepts increased student retention, student interest, and enhanced student achievement. McConnell et al. (2006) related teaching to achievement: "Underlying improved teaching is a desire to enhance student comprehension, thereby promoting a scientifically literate society" (p. 62). The studies by Adams et al. (2006) and McConnell et al. (2006) used surveys in one form or another to extract information about a student population that could be used to grow or improve some aspect of a STEM discipline.

Desired faculty characteristics. The Higher Learning Commission (HLC) (2013) requires all college instructors to be appropriately credentialed, current in their discipline, and adept in their teaching role. Faculty create the curricular pathways through which students gain needed competencies and skills (HLC, 2013). Faculty teaching at higher education organizations should have completed a degree with substantial coursework above the level being taught (HLC, 2013). Community colleges generally translate this coursework requirement to indicate faculty should have a master's degree or higher to teach general education courses and substantial coursework in the discipline of those courses.

Atkinson and Mayo (2010) identified faculty qualifications as a mix of knowledge and experience that will benefit students. By defining qualifications in terms of knowledge and experience, Atkinson and Mayo (2010) simply acknowledged some people may be qualified to teach in areas of their professional documented expertise without holding a degree in that area. It is important to note technical, career education accrediting bodies place an emphasis on industry certifications and documented recognition when defining experience as a requirement for qualified faculty (HLC, 2013). Having experience in a discipline is not the same has having tested teaching experience, according to Atkinson and Mayo (2010).

The HLC's (2013) language suggests the experience is included to accommodate the wide variety of technical programs offered at colleges, which are not typically advanced degree subject areas, such as welding, construction, and other industrial trades. While there may also be instances where the tested experience may apply to allied health, HLC (2013) does specifically mention master's degree for general education subjects.

According to Atkinson and Mayo (2010), talented teachers, not necessarily formal credentials, will lead to improved student learning.

Teaching has been identified as the espoused value driving the hiring process for full-time community college faculty (Green & Ciez-Volz, 2010). One researcher determined real teaching is what community colleges do, and student learning is the goal (Twombly, 2005). While four-year institutions are generally research focused, community colleges are oriented to teaching a wide variety of students, and therefore, must employ faculty as teachers and not researchers (Twombly, 2005). Emphasizing teaching places the student's learning first, and as a result, the opinions of the student become a part of the equation determining teaching effectiveness (Gasiewski et al., 2012).

Effective community college teachers possess qualities to positively affect student learning across a wide variety and diversity of community college students (HLC, 2013). Twombly (2005) identified the following faculty qualities as specifically relevant to the community college: the ability to communicate knowledge in a meaningful and engaging manner; enthusiasm for teaching; respectfulness of diverse peoples and views; warmth, openness, and accessibility for students; creative; flexible; caring and empathetic; humorous; cooperative and collegial; encouraging; and motivational. While many education professionals may agree these qualities are desirable, such descriptors are not always included in written job descriptions.

Additionally, it may not be appropriate to include all these criteria in a job description, since these characteristics can be examined in an interview and through reference checks (Clement, 2008). Once the qualities desired in a faculty applicant are determined, there is evidence to suggest these qualities can be specifically examined through thoughtful interview planning (Green & Ciez-Volz, 2010). Clement (2008) wrote in, *Improving Teacher Selection with Behavior-based Interviewing,* that past behavior is the best predictor of future performance, and asking interview questions requiring the interviewees to speak about things they have done can be a useful tool. This self-reporting approach is in contrast to the typical interview scenario leading with, *what would you do if*, or, *tell me about yourself* (Clement, 2008).

Teaching in community colleges requires skills to address the myriad challenges facing students (Gnage & Drumm, 2010). Community college teaching challenges are often far beyond what a university professor faces (Gnage & Drumm, 2010). Finding faculty who fit with the community college mission should also be addressed during the interview and hiring process (Green & Ciez-Volz, 2010). While a hiring process may lead to a faculty member who is competent in his or her discipline, it doesn't always lead to a faculty passionate and engaged in student learning.

Community colleges, on occasion, turn to student surveys to ascertain elements of faculty teaching qualities that are difficult to assess using conventional methods (Lloyd & Eckhardt, 2010). Due to the increasing amount of credibility placed on student surveys, several researchers have tried to quantify the thought processes students employ to reach their conclusions on faculty evaluations (Green & Ciez-Volz, 2010; Lloyd & Eckhardt, 2010; Pietrzak, Duncan, & Korcuska, 2008). Pietrzak et al. (2008) examined the relative importance of four attributes of decision-making for student evaluation of teaching effectiveness: perceived knowledge base of the professor, professor's delivery style, course organization, and course workload. The criteria used by students varied greatly overall, and knowledge base and delivery style were rated as twice as important as organization and course workload (Pietrzak et al., 2008).

The opinion and thought process of the student is valuable information to consider when evaluating and hiring teachers, and when combined with other teacher qualities and performance indicators, it can lead to an improvement in new faculty selections (Green & Ciez-Volz, 2010; Twombly, 2005). It is important to note the Pietrzak et al. (2008) was more interested in how students decide about the effectiveness of teachers, not the ways in which teachers are effective. All student surveys are not designed to evaluate teaching effectiveness, or even student perception of teaching effectiveness (Gasiewski et al., 2012). While some surveys are designed to provide feedback to the faculty member, other are meant to inform future students during the registration process (Fowler, 2009). The purpose of the survey should be well-understood by faculty, administrators, and students alike.

Faculty have been described previously as both the backbone and the Achilles heel of a community college (Hong & Shull, 2010). Hong and Shull (2010) noted faculty can be often perceived by students as significant sources of support, or the root of their frustrations, and further contended this was one of the reasons for low retention rates in science, technology, engineering, and math. It is estimated the United States will produce less than 15% of all STEM students, down from 50% in 1960 (Hong & Shull, 2010).

In an effort to increase STEM student retention, student surveys have been conducted (Hong & Shull, 2010; Lavin, Carr, & Davies, 2009). Researchers found students often cited poor teaching and the lack of supportive faculty as reasons for not continuing their chosen field of study (Hong & Shull, 2010). While students may describe faculty in informal terms, such as *nice, rude*, or *cool*, the sentiment conveyed should be taken seriously, as these faculty attributes will determine the success or failure of some students reaching their academic goals (Lavin et al., 2009). Hong and Shull (2010) recommended educators to at least understand the impact the faculty have on students and to recognize students do benefit from the energy and enthusiasm of their faculty.

Student perceptions of the quality of their faculty are highly influenced by observations made on the very first day of class (Jenkins, 2011). The first day of class is when students are forming opinions and making judgments, fair or otherwise, about their teacher (Jenkins, 2011). Things as simple as a faculty member's attire can influence student opinion before any words are spoken (Lavin et al., 2009).

In a 2009 study, Lavin et al. showed a group of students photographs of a male professor dressed in business, business-casual, and casual attire, and the students then answered 17 questions about their impressions of the faculty member. In general, the students had a higher opinion of the more professionally attired faculty and perceived the person in the photograph as being more knowledgeable, better prepared, and a more effective teacher (Lavin et al., 2009). However, the students also perceived the more casual dressed faculty to be more approachable and open to discussion, as well as probably more able to apply problems to real world scenarios (Lavin et al., 2009).

Solinas et al. (2012) emphasized the ability of the professor to encourage and maintain the interest of the student was an important factor in student retention. In the Lavin et al. (2009) study, it is important to understand student opinions and perceptions had very little to do with actual teaching effectiveness, as the experiment dealt with hypothetical faculty and student perceptions of photographs. Student perceptions of their teachers attire, while limited in its applicability to teaching ability, does provide information about the judgments made by classroom students.

Recognizing the importance of good teaching is not limited to the United States (Hvistendahl, 2009). Hvistendahl (2009) noted China is not only infusing millions of dollars into research, but Chinese educators are reinventing their undergraduate curricula to inspire creative thinking. China’s leaders have recognized in order to educate world-class students and compete with the United States, educators in China would have to re-invent their education system (Hvistendahl, 2009). China has invested nearly 6% of its annual budget in higher education and has risen to second in the world in biomedical research publication (Hvistendahl, 2009; National Academy of Sciences et al., 2010).

China’s education officials are trying to emulate the American education mode, which provides a broad educational base for mainstream students, rather than trying to identify specialized skills early in the educational process (Hvistendahl, 2009). To do this, China’s education officials are trying to attract American university professors to teach in their system (Hvistendahl, 2009). American university professors are adept at getting research dollars that may improve China’s higher education system (Hvistendahl, 2009). China has recognized while a faculty focused on research may bring in the research dollars, a faculty inspiring creativity in the students will likely lead to the student learning outcomes they are seeking to achieve (Hvistendahl, 2009).

Undeveloped majors. A prominent subject represented in the STEM major growth portion of the literature deals with how to attract women and minorities to STEM fields. Women fill nearly half of all the jobs in America, but only 25% of the STEM jobs (Beede, Julian, & Langdon, 2011). Milgram (2011) highlighted the importance of recruiting female students into STEM majors by focusing on answering the question: Why is it important to have more women in STEM?

The limited number of women in leadership roles within STEM education is a missed opportunity for both women and education (Milgram, 2011). Milgram (2011) explained increasing the numbers of women choosing STEM education as students could greatly affect the quality and breadth of the problem solving characteristics of the STEM workforce. Milgram (2011) expressed how women bring a different perspective that shapes and influences STEM disciplines:

> Having more women in the picture will not only help women themselves, it will also help society benefit from their expertise whether it's ensuring women are included in clinical trials for medical re-search or developing a prosthetic knee that works better for women. We are all enriched when women fully contribute to science and technology. (p. 5)

The U.S. Commission on Civil Rights (2010) stated that recruiting women into STEM educational fields is only part of the solution to increasing women in STEM careers. Since the pool of qualified STEM aspirants is relatively small compared to other fields, limited resources would be better spent on increasing the size of the pool by focusing on skill building within pre-STEM programs targeting women (U.S. Commission on Civil Rights, 2010).

Outreach programs have been effective tools for promoting STEM careers to women entering higher education (Milgram, 2011). A program to place marine science majors in contact with the public at aquariums to improve scientific information communications has helped students entering the workforce in their field of study (Halversen & Tran, 2010). Peer mentoring programs for freshman engineering students have helped reduce the dropout rate at the University of Pittsburg (Budny et al., 2010). Electronic media enhancements grants from the National Science Foundation have been identified as necessary in directing student-teacher interaction at schools around the country (National Science Board, 2010). Research Experiences for Undergraduates (REU) programs have been shown to be effective mechanisms to recruit undergraduate students into the sciences and also to retain them, especially underrepresented students (Gibson & Bruno, 2012). These specific, focused outreach programs succeed by supplying motivational and practical tools to students and teachers to achieve an academic or career impacting result (Budny et al., 2010; Gibson & Bruno, 2012; Halversen & Tran, 2010; Milgram, 2011).

Due to the underrepresentation of certain demographic groups in STEM education and careers, it can be deduced that members of these demographic groups have decided not to major in STEM areas (Gasiewski et al., 2012; NEC et al., 2011; NRC, 2007). Ajzen (1991) attempted to explain this decision through the TPB:

> Those who believe that they have neither the means nor the opportunities to perform a certain behavior are unlikely to form strong behavioral intentions to engage in it, even if they hold favorable attitudes toward the behavior and believe important individuals would approve of their performing such behavior. (p. 134)

Researchers conclude women and minorities have not chosen STEM education, not due to a lack of interest, but rather from the lack of role models to which they can identify with and be mentored by (Lips & McNeill, 2009; Page, Bailey, & Delinder, 2009). In a 2009 outreach effort by California Institute of Technology and City College of San Francisco's Computer Networking and Information Technology (CNIT) program, an increase of female student participation by 12% was recorded the first year and again by 15% the second year of the initiative (Milgram, 2011).

A student choosing to major in a STEM academic area and a student choosing not to major in a STEM academic area are both applying, to varying degrees, the three constructs of the TPB (Ajzen, 1991; Tan & Laswad, 2009). Referents have been shown to influence students' major choice decisions, especially among women and minorities (Toulmin & Groome, 2007). Programs and initiatives designed to increase STEM area involvement and retention have proven effective possibly, in part, due to the referents provided to the student from the program or initiative. When students deciding on a college academic major are lacking informational sources for any of the constructs of the TPB, programs and initiatives targeting these students can act as a referent surrogate (Ajzen, 1991; Tan & Laswad, 2009). Since most programs and initiatives are subject, or at least area specific, participants' decision-making tools could be enhanced allowing the student to make more informed academic major-related decisions. Science, technology, engineering, and math specific programs and initiatives have shown to increase participation in STEM academic areas by supplementing a student's decision-making tools with positive, encouraging STEM referents (NEC et al., 2011).

STEM Educational Pedagogies

Gallant (2010) summarized the importance of integrated STEM coursework and maintaining qualified, inspirational teachers by relating the need for a well-prepared workforce to the preparatory and inspirational role parents, teachers, and policy makers play in advancing the STEM curricular environment. Gallant (2007) emphasized the end result of an effective integrated program could be increasing student content knowledge, thus improving achievement in mathematics and science. A key component of Gallant's (2010) assertion is the specificity of the teachers' role in creating student motivation.

Student motivation created by the teacher could be maintained, and persist into the workforce, by applying an effective STEM-specific pedagogy (Gasiewski et al., 2012). Sanders (2009) stated that integrated STEM pedagogy is a specific application of educational practices that are intended to engage students and promote scientific inquiry by design. A robust learning environment, according to Sanders (2009), is one that engages students and groups of students in problem solving and student-initiated scientific inquiry. Sanders (2009) admitted a skepticism when reading or hearing STEM used to imply something new and different in educational practices. Upon closer inspection, many of the STEM-labeled programs and/or initiatives are in no way integrated and continue to approach education from the traditional separated subject matter structure (Sanders, 2009).

Traditional science and math curricula have produced some of the top scientists and mathematicians around the world, but an integrative approach could produce a larger number. The concern is too many young students are dropping out of these traditional rigorous programs (Atkinson & Mayo, 2010; Lips & McNeill, 2009; National Academy of Sciences et al., 2010). The integrated approach to STEM is intended to attract and retain students who otherwise would have left the STEM fields all-together (Sanders, 2009). The need for a change in the way educators approach students in these courses is the result of the social and technological realities of the current generation of students

(Gallant, 2010). Gallant (2010) observed the technological age of video games, smartphones, and instant messaging is creating a culture of students familiar with constant stimuli and innate engagement within digital environments.

The traditional lecture and note-taking system for mathematics and science instruction may not continue to be an effective educational process in the modern era with the expanded use of digital resources (National Science Board, 2010). Capturing the interest of math and science students in elementary and secondary schools will require the embrace of classroom technology by teachers who know how to use it (Gallant, 2010). Significant advances have been made in the modern classroom in concerted efforts to get the attention and focus of students on presented material. However, "Enrichment is extremely valuable, particularly to inspire interest in STEM, but insufficient by itself" (National Science Board, 2010, p. 17).

While fiscal constraints often slow the modernization of more classrooms, other initiatives can be just as effective: mentoring, internships, and after-school programs can engage students to a higher degree in STEM areas (Gallant, 2010). The initiatives referred to by Gallant (2010) can be applied to integrated and traditional STEM education alike. Traditional education in the separate components of STEM may be enhanced by creating connections between independently taught subjects (Williams, 2011). Williams (2011) suggested STEM discipline interaction could be achieved through encouraged cross-training of teachers, and argued true integration is unlikely to be achieved due to rigid class schedules, curriculum structure, and classroom design. A more reasonable alternative to STEM integration could be the development of cross-curricular links and maintaining the integrity of each subject separately (Williams, 2011). Gentile et al.

(2010) found students enrolled in integrated programs are likely to take more math, science, and computer courses their junior and senior years, and emphasized these students were likely to participate in research, and make connection between subject areas earlier in their education.

Gasiewski et al. (2012) linked high attrition rates in STEM classes to several factors, including a prevalence of large lecture courses and an apparent lack of an engaging teaching pedagogy. Gasiewski's et al. (2012) study surveyed 2,873 students in 73 introductory science, technology, engineering, and math courses at 15 colleges and universities. The findings indicated students are more engaged in classes where instructors regularly and often demonstrated a clear openness to student questions and recognized their role with helping students succeed (Gasiewski et al., 2012).

There is an established link between supportive, encouraging instruction, and student satisfaction (Solinas et al., 2012). Students who reported feeling comfortable asking questions, seeking tutoring, attending supplemental instruction sessions, and collaborating with other students were more likely to be engaged in the class (Gasiewski et al., 2012). Student engagement can be increased in traditional classrooms in STEM fields (Gasiewski et al., 2012). Active learning, web-based pedagogy, and collaborative/cooperative learning are areas Gasiewski et al. (2012) reported as supportive of creating increased student engagement in traditional classrooms.

Student engagement can also be achieved through collaborations between science researchers and science educators (Campbell, Der, Wolf, Packenham, & Abd-hamid, 2012). An analysis of a 2012 study by Campbell et al. showed collaboration between science educators and genetics researchers resulted in measurable positive changes in how the course was taught, while gains were made in student engagement in the scientific inquiry process. Gallant (2010) noted increased student engagement through deliberate STEM integration has several documented benefits and further posited, “the benefits of developing and implementing an integrated curriculum include (a) students are able to connect concepts across discipline, (b) students are more motivated to learn, and (c) students score higher on standardized mathematics and science tests” (p. 5).

While a good portion of the literature on STEM issues implies a degree of integration between single subject coursework, the result of integration initiatives provide meaningful insights on pedagogies applicable to non-integrated student learning environments as well. Gallant (2007) summarized the challenges to overcome in the integrated approach by identifying the need for more teacher collaboration, improving classroom scheduling, and improving teachers’ classroom management skills. Gentile et al. (2010) found a key missing evaluative measure was the communication between first- and second-year teachers about the preparedness of the entering students, then using this information to ensure the first year classes are better prepared.

Both Gallant (2007) and Gentil et al. (2010) identified problems and challenge areas in integrated programs common to traditional non-integrated coursework and documented the varying degree to which instructors of integrated science programs differ in opinion regarding the effectiveness of student learning in these environments. Coalescing a faculty around any single pedagogy is problematic. A 2009 study by Dickman, Schwabe, Schmidt, and Henken analyzing the effectiveness of an integrated STEM program, concluded the primary challenge was maintaining a focus on critical thinking and problem solving. Dickman et al. (2009) further expanded their conclusion by raising the question of teacher credentials for integrated STEM courses. Finding teachers knowledgeable in the subject matter and also possessing the ability to effectively promote student performance in the areas of critical thinking and problem solving may also be a challenge in non-integrated classes. Finally, Osborne et al. (2007) surveyed integrated STEM results and offered the critique that students would benefit from more practical applications and discussion time in the integrated courses. The parallels of the challenges of integrated STEM courses and traditional, non-integrated courses may be similarly apparent to educators from both realms.

STEM Workforce

Studies show the American STEM workforce demands a greater number of qualified graduates than the educational system is producing (NSB, 2012). As a result of this workforce demand, the higher educational system in the United States is under pressure to produce more qualified STEM graduates (The President's Council of Advisors on Science and Technology, 2012). Carnevale et al. (2011) divided science, technology, engineering, and math occupations include five major subgroups: (a) computer occupations; (b) mathematical science occupations; (c) architects, surveyors, and technicians; (d) engineers and engineering technicians; and (e) life and physical science occupations. Carnevale et al. (2011) projected a 17% growth in these fields by 2018. This high rate of growth for STEM occupations in the future will only be surpassed by healthcare occupations (Carnevale et al., 2011). The DOL (2007) identified the importance of growth in STEM fields as vital to United States economic growth and competitiveness. Long-term strategies developed for increasing worker standards of living and greater opportunity require public, private, and not-for-profit coordination

(DOL, 2007). The size and quality of the American workforce is directly affected by the number of college students choosing to major in science, technology, engineering, and math. (Winters, 2009). Lips and McNeil (2009) warned that the declining number of graduates in STEM academic fields will result in a diminished ability of the United States to compete globally.

Educational pipeline. Efforts to invigorate United States STEM competitiveness generally focus on the pipeline model supplying STEM educated talent to the workforce (Ewell et al., 2003). The positive effects economic factors play in attracting an educated workforce are important, but the educational system is the key component for sustained progress towards workforce improvement (Ewell et al., 2003). Kuenzi (2008), in a report to Congress, frequently referred to expanding the pipeline when summarizing the United States government's role in STEM advancement.

Critics of this model expressed concern that more attention should be given to the demand component and less to the supply side of workforce needs (Metcalf, 2010). Metcalf (2010) identified the universal acceptance of the pipeline model while emphasizing the workforce importance as a catalyst for increasing education attainment from a demand perspective. Metcalf (2010) contended the data upon which many STEM initiatives rely may be improved by inclusion of factors that better represent the complexities of a workforce in flux:

> As economic and national investment in STEM continues to grow, even in a time of proclaimed economic crisis, it is particularly important to take a critical eye to the assumptions, values, and limitations of the pipeline model and its manner of understanding educational pathways. (p. 15)

Researchers have identified specific instances where the pipeline educational model seems to effectively characterize a STEM workforce shortage (Carnevale, Smith, & Strohl, 2010). Carnevale et al. (2011) reported, "Siemens has reported 3,200 open but seemingly un-fillable jobs, and in Michigan, Nexteer Automotive is looking for 100 engineers, but is having a hard time finding qualified workers" (p. 16). While several researchers and government reports list labor statistics to validate their prediction of a STEM worker shortage, other researchers deemphasize the magnitude of the anticipated shortage (Carnevale & Smith, 2011; Dickman et al., 2009; Metcalf, 2010). Dickman et al. (2009) contended workforce opportunities create a demand for well-prepared STEM students, while emphasizing the importance of not overlooking the effect a large supply of graduates has on the creation of new, innovative technologies, and products. Both the workforce demand and the STEM graduate supply should be considered when analyzing the interrelated effects one has on the other (Metcalf, 2010).

A complete analysis of the educational pipeline may require the acknowledgment of the complexities of global economics, and the intricacies of the education-workforce relationship. Metcalf (2010) cautioned grouping fields and people together within the STEM designation "has a tendency to homogenize and oversimplify the complex ways that people learn, work, and identify themselves" (p. 9). Carnevale et al. (2011) contended some of the debate surrounding the STEM supply and demand issues can be explained by examining the desire for STEM skills throughout the economy.

Occupations other than STEM occupations are diverting STEM workers out of the pipeline, creating a workforce deficit (Carnevale et al., 2011). The critical thinking and problem solving skills possessed by STEM graduates are valuable to employers outside the STEM occupational area (Carnevale et al., 2011). Additionally, graduates uninspired to seek employment in their degree field could have resulted from a disenchantment of the student as to their ability to solve meaningful problems (Foster, 2010).

Educational pedagogies emphasizing student inspiration and confidence could limit the number of students seeking employment outside the STEM area (Carnevale et al., 2011). While this phenomenon may account for the abundance of STEM graduates per STEM vacancies argument, the reality still exists that more STEM graduates are needed to replace those siphoned off to other occupational areas. A failing economy and lowered standards of living are possible outcomes if the United States does not invest in high quality, knowledge-intensive jobs leading to innovative enterprises, discovery and new technology fields (NRC, 2007). Acknowledging the importance of maintaining a high STEM proficiency, the literature presents a range of educational focus areas to address the real, or perceived, American STEM deficiencies.

Higher education attainment. Carnevale et al. (2011) provided a specific regional study on the challenges facing the STEM workforce in midwestern United States. As a result of the economic downturn of 2007, many low and middle income workers lost jobs in farming and manufacturing (Carnevale & Smith, 2011). These jobs are not expected to return, and are expected to be replaced by jobs in STEM occupations (Kuenzi, 2008; National Academy of Sciences et al., 2010) Carnevale et al. (2011) explained the STEM jobs of the future, in the midwest United States specifically, “will require a higher level of education attainment than was required by the pre-recession workforce” (p. 6). These workforce requirement findings are synchronous with national trends (NEC et al., 2011). More jobs nation-wide are requiring some form of higher education (Carnevale et al., 2010). The need for a more highly educated workforce is also prerequisite for the innovation desired for global competition (Carnevale et al., 2011). Atkinson and Mayo (2010) explained:

> Just as we would be unable to expand industry if we lacked the natural resource materials to build the factories (e.g., cement), or energy to power the plants, we cannot expand our technology economy without the needed human resources, in this case high-quality STEM graduates. (p. 22)

Educational attainment rates have been aligned with technological innovation around the globe (National Academy of Sciences et al., 2010). The Organization for Economic Cooperation and Development (OECD) is a group of 30 countries joined in an effort to increase the quality of life of their citizens (National Academy of Sciences et al., 2010). In 2011, the United States was ranked 9th among OECD countries in the percentage of young people obtaining a college degree. Tapping America's Potential (TAP) (2008) established a goal of doubling the number of STEM graduates with bachelor's degrees from 2005 to 2015. This group of American business leaders, in 2005, formed to raise awareness on the importance of the United States government's role in supporting innovation.

In 2008, TAP reported the United States was "gaining momentum, but losing ground" (p. 1). and expressed concern for America's competitive future by relating government support to business innovation around the world. The TAP (2008) progress report communicated the frustration coming from America's business leaders: "while governments around the world are building their national innovation capacity through investments in research and STEM education, the United States is standing still. Failure to change [this] status quo places America's future economic and technological leadership at risk" (p. 2).

During this time, the United States Congress passed the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (COMPETES) Act, which addressed many of the concerns expressed by TAP in 2005 (Kuenzi, 2008). The America COMPETES Act was a significant step towards enhancing the United States innovation capacity, if properly funded (TAP, 2008). Tapping America's Potential (2008) recommended the U. S. government should follow-through with the America COMPETES Act by funding basic university research, funding STEM education programs, enacting immigration reforms to attract foreign-born professionals into the United States, and encourage state, local, and private-sector initiatives.

Immigration. The American economy and workforce have been greatly enhanced by professionals who were foreign-born and immigrating to the United States (NRC, 2007). For example, "One-quarter of all companies founded in these sectors [engineering and technology-related industries nationwide] from 1995-2005 had at least one immigrant key founder; and these firms contribute substantially both to job and wealth creation in the… [United States]" (Wadhwa, Saxenian, Rissing, & Gereffi, 2008, p. 13). Kuenzi (2008) raised concerns regarding the number of degrees awarded to foreign students, as compared to those awarded to United States citizens. Kuenzi (2008) reported over half of the engineering degrees awarded in the United States are earned by foreign students, and while most of these students remain in the United States workforce after graduation, these students still represent foreign expertise. Kuenzi (2008) further noted:

> The increased presence of foreign students in graduate science and engineering programs and in the scientific workforce has been and continues to be of concern to some in the scientific community. Enrollment of U.S. citizens in graduate science and engineering programs has not kept pace with that of foreign students in these programs. (p.15)

Increased American participation in STEM occupations through higher education attainment is a priority for the United States government, educators, and business leaders (Kuenzi, 2008; NRC, 2007; TAP, 2008). Instilling confidence in potential STEM students attending introductory coursework by linking workplace-related problems and skills developed in the classroom could reduce student major choice uncertainty.

Despite the United States government's efforts to improve America's STEM proficiencies, measurable improvement has not been achieved on a wide scale. Government expenditures on STEM related initiatives totaled approximately 3 billion dollars in 2004 and remained at that amount in 2007 (National Science Board, 2010). The effectiveness of programs funded was examined in 2007 with the U.S. Department of Education's report of the Academic Competitiveness Council (ACC). The U. S. Department of Education pointed out: "After a review of the [STEM education] examples submitted, the ACC concluded that 'there is a general dearth of evidence of effective practices and activities in STEM education'" (U.S. Department of Education, 2007, p. 3). Faculty considering innovative teaching approaches and inspirational classroom activities could be encouraged that their efforts may contribute to STEM education improvement to solve problems that have yet to be identified.

Summary

Leading innovation in STEM areas has been on the United States' agenda since the 1960s when Russia won the space race with the Sputnik satellite (Peoples, 2008). By focusing on factors contributing to national educational excellence in STEM fields, the United States can retain and improve its world rank in innovation, competitiveness, and security (DOL, 2007). Improving STEM education will require a focus on both preparation and inspiration of students (President's Council of Advisors on Science and Technology, 2012). A focused national effort to increase the number and quality of STEM graduates in the United States has been ongoing in the United States (NEC et al., 2011).

Inspiring and engaging students in the classroom may increase student confidence in their choice of academic major and eventual career decisions. Bretell and Ault (2010) found students frequently state they would be more likely to continue with their college education if they were more informed and confident about their choice of academic major. Students may be predisposed to choose a particular academic major based on their own unique qualities (Tan & Laswad, 2009). Tan and Laswad (2009) found students' perceptions of their own skills are an important factor when students decide on a college major. Students use factors such as aptitude, interest, and job availability while deciding on their college major (Porter & Umbach, 2006).

The role faculty play in student learning, motivation, and retention in science cannot be over-emphasized. Several authors have used surveys to learn student characteristics and learning outcomes within the STEM fields of study (Adams et al., 2006; Atkinson & Mayo, 2010). Adams et al. (2006) studied two aspects of STEM education; the impact of teaching styles on the likelihood of students becoming physics majors and difference in learning styles of male and female physics majors. Atkinson and Mayo (2010) determined faculty qualifications should be composed of a mix of knowledge and experience that will benefit students. A student choosing to major in a STEM academic area and a student choosing not to major in a STEM academic area are both applying, to varying degrees, the three constructs of the TPB (Ajzen, 1991; Tan & Laswad, 2009).

Classroom teachers and mentors have been shown to influence students' major choice decisions, especially among female students and students from traditionally underserved ethnicities (Toulmin & Groome, 2007). Researchers conclude females and from traditionally underserved ethnicities have not chosen STEM education, not due to a lack of interest, but rather from the lack of role models to which they can identify with and be mentored by (Lips & McNeill, 2009; Page et al., 2009). Increasing the number of mentors among women and minorities could, in turn, increase participation of women and minorities as students in STEM educational fields (United States Commission on Civil Rights, 2010).

While traditional science and math curricula have produced some of the top scientists and mathematicians around the world, an integrative approach could produce a larger number of qualified graduates (Sanders, 2009). Too many young students are dropping out of these traditional rigorous programs (Sanders, 2009). The integrated approach to STEM is intended to attract and retain those students who otherwise would have left the STEM fields (Sanders, 2009). While fiscal constraints often slow the modernization of classrooms, other initiatives, such as mentoring, internships, and after-school programs, can be just as effective at engaging students to a higher degree in STEM areas (Gallant, 2010).

Studies show the current American STEM workforce demands a greater number of qualified graduates than the educational system is producing (National Science Board, 2010). The number of graduates in these academic fields has been on the decline in the United States since the 1960s, which, according to Lips and McNeil (2009), has resulted in a diminished ability of the United States to compete in science and engineering on the world stage. Despite the United States government efforts to improve America's STEM proficiencies, measurable improvement has not been achieved on a wide scale.

The chapters that follow will present the study-specific details pertaining to research design, methodology, population and sample, collection, and analysis of data. Chapter Three will describe the methodology utilized for this study. Chapter Four will describe the type of data obtained during this study and present an analysis of the data. Chapter Five summarizes findings and presents conclusions relevant to the research questions of this study. Chapter Five will also provide a discussion of the findings as they relate to problems and challenges identified in Chapter Two.

Chapter Three: Methodology

The United States relies on its education system to produce workers in the areas of science, technology, engineering and math (STEM) in order to compete globally (Atkinson & Mayo, 2010). Studies show the current American STEM workforce demands a greater number of qualified graduates than the educational system is producing (National Science Board, 2010). As a result of this workforce demand, the higher educational system in the United States is under pressure to produce more qualified STEM graduates (The President's Council of Advisors on Science and Technology, 2012).

The number of STEM graduates currently produced by American higher education institutions, as measured by degree completion, can be seen as result of a series of decisions made by STEM degree seeking students (Kalevitch et al., 2012). This study proposed to survey the decision-making criteria science students use, and the motivational sources reported by these students when deciding to pursue a science major. Knowing and understanding these decision-making criteria and motivational sources of STEM degree seeking students could lead to the development of initiatives aimed at increasing the number of students completing STEM degrees at American higher education institutions (Tan & Laswad, 2009).

Problem and Purpose Overview

It was estimated in 2010 the United States would produce less than 15% of all science, technology, engineering and math (STEM) students worldwide (Hong & Shull, 2010). This represents a significant decrease from the 50% the United States produced in 1960 (Hong & Shull, 2010). The United States has consistently shown it is unable to produce enough of its own STEM workers in key fields (Atkinson & Mayo, 2010).

Surveys found students often cited poor instruction and the lack of supportive faculty as reasons for STEM students not continuing their chosen field of study (Hong & Shull 2010). To improve STEM education and increase student participation in STEM areas, higher educational institutions must focus on both preparation and inspiration of students (President's Council of Advisors on Science and Technology, 2012). The faculty role in motivating students and maximizing student learning is critically important. Faculty can often be perceived by students as significant sources of support or the root of their frustrations (Hong & Shull 2010). According to a study conducted by Malgwi et al., (2005) college students decide on their academic major during their first major class. Introductory courses in all disciplines have been shown to be obstacles to student persistence and degree completion (Zeidenberg, Jenkins, & Scott, 2012). Introductory STEM courses, in particular, may deter prospective majors due to their breadth and rigor (National Science Board, 2010).

The purpose of this research study was to gain insight into the decision-making processes students employ as they relate to the selection of an academic major in science, technology, engineering, or math (STEM.) Knowing, understanding, and addressing these factors could possibly lead to changes in how instructors approach students which could result in an increase in the number of students declaring a STEM area academic major in the United States.

Research questions. This research proposed to provide answers to the following questions:

1. What motivation factors are most likely to be reported by college students in pursuit of a STEM major?

2. What differences exist, if any, in the types of motivation factors reported by STEM students as disaggregated by the types of higher education institutions they attend?
3. What differences exist, if any in the types of motivation factors reported by STEM students as disaggregated by age and sex?

Research Design

This study employed a quantitative approach to obtain results to answer the research questions. Quantitative approaches allow results to be expressed in measurable, numerical terms (Creswell, 2009). It was the intention of the researcher to obtain data describing decision-making and motivational variables within the identified sample population. This research study was designed to provide descriptive data through the use of a survey instrument. Surveys can effectively describe aspects of a population's opinions, attitudes, and beliefs (Fraenkel, Wallen, & Hyun, 2009).

A qualitative component to this research was considered during the preliminary design phase, but was ultimately ruled out based on a review of the literature, projected data needs, and the desire to effectively communicate findings to STEM faculty. Research conducted in STEM fields relies on empirical evidence to guide decisions, articulate ideas, and communicate findings (Creswell, 2009). The STEM subject matter presented in this research was intended to be impactful to the STEM educational field comprised primarily of individuals trained in these empirical methodologies (Bluman, 2009). Creswell (2009) explained the assumptions made in empirical science are more appropriately investigated with quantitative research than qualitative research. Furthermore, the President's Council of Advisors on Science and Technology (2012) identified the need for empirically validated teaching practices in STEM educational areas.

Population and Sample

The population of this study was students majoring in biology who attended higher education institutions in the Midwest. The schools were selected based on their location, size, science degree offerings, and their status as a public, private, two-year, and four-year institution. The sample was generated and divided into cluster samples (Bluman, 2009). This quantitative approach was appropriate because the participants were divided into groups based on the type of institution they attend (Bluman, 2009). Creswell (2009) noted cluster sampling employs multi-stage sampling by first selecting the institution of a specific type, then identifying the participants to which surveys will be distributed. The total population will be representative of students from all four institution types. Steps were incorporated into the study to avoid any influences affecting the participant’s willingness to take part in the study (Fowler, 2009).

Instrumentation

The data collection tool utilized for this study was a survey. The quantitative survey method of data collection was utilized in order to produce numerical descriptions of the study population needed to answer the research questions (Fowler, 2009). A survey which uses a five-point scale was used to obtain data for the study (Glynn et al., 2011). The purpose of the survey was to collect data which can be generalized from a sample to a population, so that inferences can be made about the characteristics, attitudes, and behaviors of this population. The questionnaire utilized, with permission, was the *Science Motivation Questionnaire II* (SMQII) © 2011 by Shawn M. Glynn (see Appendix A). This questionnaire has been validated for use in research investigating the motivation of science students and includes specific criteria students may contemplate when deciding on an academic major (Glynn et al., 2011). Survey questions conform to the student motivation and perceived success framework by limiting their scope to those criteria identified as constructs of Ajzen's (1991) Theory of Planned Behavior (TPB). It was anticipated students would find the range of response options appropriate to the topic questions being asked. Malgwi et al. (2005) determined students cite identifiable factors in their major selection decision-making process. Demographic data on each participant were also collected to provide a framework for the data analysis.

The SMQII consists of a 25-item questionnaire (Glynn et al., 2011). In order to learn attributes of the sample population which are outside the realm of the questionnaire developed by Glynn et al. (2011), six questions were included as an addendum to the survey by the researcher, for a total of 31 questions. To preserve validity of the SMQII, the additional five questions were treated as a separate, stand-alone survey during analysis. It was estimated based on the length of the questionnaire, and the amount of input requested by the participants, that the questionnaire would require approximately15 minutes to complete. The questions were based on specific identifiers associated with how college students select their academic major (Glynn et al., 2011).

The SMQII identifies five factors associated with science student major selection: intrinsic motivation, career motivation, self-determination, self-efficacy, and grade motivation (Glynn et al., 2011). The questions added by the researcher addressed a student's motivational source. Each question was answered with a selection from a five-point scale. The scale limited participant responses across a range enabling the researcher to comparably discern student motivational factors (Fowler, 2009). The limited scaled response options assisted the researcher in identifying and analyzing trends in the sample results. Conclusions were reached based on an analysis of data, and the statistical estimates made from those data (Fowler, 2009).

The SMQII was converted to a digital format to allow for online data collection. Glynn et al. (2011) give permission to educators who wish to use the questionnaire for research and teaching provided they comply with the fair use of this copyrighted and registered work. The SMQII was used in its entirety. The additional six questions focusing on source of motivation represented an area in which the researcher desired more information.

Data Collection

Prior to sampling, the SMQII and the additional researcher-created questions were tested by a three-person review committee. Committee members were chosen from biology faculty and education administrators who would not participate in the actual study. Committee member selection was partially based on the potential member's professional role and associated knowledge of issues in science, technology, engineering, math, teaching, and enrollment trends in higher education. Upon finalization by the committee, the SMQII and the researcher's additional questions were field-tested on students not participating in the study to ensure consistent and meaningful data were gained during the sampling phase of this study.

Approval of this research study by the Lindenwood University Institutional Review Board was obtained (see Appendix B) and letters requesting permission to access participants were sent to selected schools (see Appendix C). The survey distribution process was initiated after the researcher received written permission from the schools. The survey was administered using an internet-based survey tool accessed through

Kwiksurveys.com. A link to the survey was e-mailed to the instructors at each of the schools representing the cluster to be sampled. The contact person then distributed the link to the questionnaire to all potential participants.

Information about the participant was asked in the beginning of the survey instrument followed by the questions. Each question was followed by a scaled response section based on a five-point scale. Information was available to the participant regarding the identity of the researcher, the purpose of the research, and contact information for the researcher. After analysis was complete, all data gathered from the surveys were stored digitally in a password-protected file on an external computer hard-drive and stored in a safe deposit box for a period of three years starting from the date on which the survey was distributed. These security measures were used to protect the participant' privacy and ensure the confidentiality of the responses (Fink, 2013).

Data Analysis

Completed survey results were downloaded from the survey web site and the data were imported into an Excel file for descriptive analysis. Two types of data were analyzed in this study; ordinal data and interval data.

Ordinal data analysis. According to Bluman (2009), ordinal scale data is defined as data that can be expressed in ranked groups; "however precise differences between the ranks do not exist" (p. 8). The central tendency of ordinal data is most accurately represented by the median or mode (Boone & Boone, 2012). Summarizing ordinal scale data by calculating the statistical mean is inappropriate as it would lead to result which could fall at increments between actual survey choices, rendering the result meaningless. The purpose of the ordinal data collected in this survey was to discern trends in a student's type and source of motivation when deciding on science as an academic major. Students selected their response to these questions from the choices by completing the sentence, *I majored in science because*. For each of the six sentence completions provided in the survey, the student ranked the source of motivation by choosing one of the following qualifiers: *strongly disagree, disagree, neutral, agree, or strongly agree*. These responses were converted to ranked values; 1 for strongly disagree, to 5 for strongly agree. In this study, responses of *agree* and *strongly agree* were considered positive responses for the specific motivational source, while responses of *disagree* and *strongly disagree* were considered negative responses.

Interval data analysis. When the responses to several questions are grouped together for analysis, they may be considered interval data that can appropriately be described with the central tendency statistic of a mean, or average (Boone & Boone, 2012). In this study, the responses to the five researcher-generated survey questions designed to inquire about student motivation type were averaged, which resulted in a composite score for each motivation type. Composite scores were averaged for groups of students for the purpose of comparing those groups (e.g. school type, age and sex).

Analysis of the data from this study included a percentage comparison of the five possible responses to each question. Observable differences between responses recorded for a question allowed the researcher to ascertain whether the subject of the question influenced the student (positive response) or did not influence the student (negative response). As noted before, this study adopted the composite approach characterized by Glynn et al. (2011) to analyze student response to five motivational factors: intrinsic motivation, grade motivation, career motivation, self-efficacy, and self-determination.

The survey consists of five questions for each of the motivation types, for a total of 25 questions. Each question required a response from a five-point scale. The students selected from *never, rarely, sometimes, usually*, and *always* to rank given responses to the statement; *When I am in a college science course.* These responses were converted to numerical values, one for *never*, to five for *always*, to analyze the data generated. Student responses for each of the five questions within a motivational group were averaged to generate a composite score used to characterize that student's overall response to those questions as a group.

Frequency tables were used to compare results of the survey between each school. Frequency tables summarize data by tabulating how often values occur within a data set (Bluman, 2009). Survey result comparisons between institutions allowed the researcher to discern factors affecting one school's students' major choice decisions from those of another school. Participants' survey data were then examined to determine the source and type of motivation the participants used when deciding to major in science.

Summary

This research utilized a survey to collect information about what factors led students to decide on biology as their academic major. Quantitative data were gained through the use of a survey with a five-point scaled response. The data obtained extended the understanding of the factors utilized by students when deciding on a major. The assumptions made in empirical science are appropriately investigated with quantitative research due to the identified need for empirically validated teaching practices in STEM educational areas (Creswell, 2009; The President's Council of Advisors on Science and Technology, 2012). Ultimately, the goal of this research was to provide the data necessary for the development of initiatives that increase the number of students majoring in STEM academic areas.

Chapter Four provides an overview of the problem and purpose, a review of the instrumentation and data collection, and a detailed analysis of the data. The data analysis section presents the findings for each research question. These findings are further disaggregated by institution type and by the demographics of the participants.

Chapter Four: Analysis of Data

Science, technology, engineering, and math (STEM) have been identified as educational areas in need of improvement (Atkinson & Mayo, 2010; DOL, 2007; National Academy of Sciences, National Academy of Engineers, & Institute of Medicine, 2011; President's Council of Advisors on Science and Technology, 2012). The improvement desired would contribute an elevation in status for the United States in the area of STEM workforce readiness (Atkinson & Mayo, 2010; DOL, 2007; Toulmin & Groome, 2007). As discussed in Chapter Two, studies have shown STEM deficits in the American workforce (DOL, 2007; Metcalf, 2010; National Academy of Sciences et al., 2011; United States Commission on Civil Rights, 2010). Solutions to workforce deficits often focus on the education system that supplies capable STEM graduates prepared to enter the workforce (DOL, 2007; Ewell et al., 2003; Metcalf, 2010; President's Council of Advisors on Science and Technology, 2012).

Within education, specific areas are identified in the literature as impactful to STEM improvement. Recruitment and retention of students choosing STEM majors have been identified as areas that, if improved, could address a portion of the workforce supply concerns (Lloyd & Eckhardt, 2010). Educational pedagogies in STEM areas could be impactful on student learning which, in turn, may positively impact identified STEM workforce readiness concerns (Campbell et al., 2012; McConnell et al., 2006; Osborne et al., 2003). The STEM workforce in America can be considered a product of the quality, quantity, and composition of those graduating from American educational institutions with STEM degrees (Drew, 2011; National Academy of Sciences et al., 2010). In this chapter, the motivational factors influencing student STEM major choice, as reported by respondents to this study's survey, will be examined. Findings for each research question will be presented and discussed.

Problem and Purpose Overview

Employment in STEM fields is becoming increasingly important to the United States' economic growth and competitiveness (DOL, 2007). The United States is consistently not able to produce enough of its own STEM workers in key fields (Atkinson & Mayo, 2010). The *STEM Workforce Challenge Report* of the DOL (2007) summarized the problem by stating, "American pre-eminence in STEM will not be secured or extended without concerted effort and investment." (p. 1) The National Science Board report, *Preparing the Next Generation of STEM Innovators: Identifying and Developing our Nation's Capital* (2010) stated:

> We cannot assume that our Nation's most talented students will succeed on their own. Instead, we must offer coordinated, proactive, sustained formal and informal interventions to develop their abilities. Students should learn at a pace, depth, and breadth commensurate with their talents and interests and in a fashion that elicits engagement, intellectual curiosity, and creative problem solving—essential skills for future innovation. (p. 2)

A report by the NEC et al. (2011) predicted that America's future economic growth and competitiveness will largely depend on skills developed in STEM educational fields. This report calls for an improvement in the quality and quantity of American science education graduates (NEC et al., 2011). To improve STEM education, educators must focus on both preparation and inspiration of students in STEM academic field (The President's Council of Advisors on Science and Technology, 2012).

As stated previously, American leaders have been repeatedly calling for a larger, stronger STEM trained workforce since the 1960s (NRC, 2007). The reasons cited for STEM improvement efforts have ranged from national defense, to the economic impact of global competitiveness, and the desire for industry innovations in sustainable energy (Atkinson & Mayo, 2010; President's Council of Advisors on Science and Technology, 2012). Improving the American workforce requires STEM education that starts with students deciding to major in a STEM field.

Hong and Shull (2010) reported students make major choice decisions based in part on experiences they have with faculty teaching in STEM areas. Hong and Shull (2010) noted faculty can be perceived as significant sources of student support or the root of their frustrations, and were reasons for low retention rates of STEM students. The degree science majors base their decisions on, factors other than teaching, is not well-represented in the literature. Tan and Laswad (2009) examined the decision-making processes of accounting majors and categorized those decisions into three categories based on Ajzen's (1991) TPB.

The purpose of this research was to learn why students choose a STEM major and to determine which decision criteria most influenced this decision. According to the TPB proposed by Ajzen (1991), the key components of decision-making can be quantified and used as predictors of behavior. In this study, STEM majors' decision criteria were compared between different institution types; two-year, four-year, and private four-year, and between demographic groups; age and sex. The data gained through this research study were analyzed for trends in students' decision making process in the selection of an academic major in a STEM field. While the TPB has been used to study student major choice, it has not been used to study STEM fields specifically (Tan & Laswad, 2009). Knowing, understanding, and addressing these TPB factors could possibly lead to a change in how instructors approach students' needs (Tan & Laswad, 2009). The application of these TPB factors, in turn, could possibly impact the number of students declaring a STEM area academic major in the United States.

The quality of education is the focus of most of the STEM improvement efforts (Ewell et al., 2003). While most of these efforts focus on improving existing curriculum and pedagogy for students already in the STEM pipeline, more attention could be focused on increasing the number of students entering the STEM pipeline (Ewell et al., 2003). Increasing the number of students choosing to major in STEM could have a far greater impact on increasing and strengthening the STEM workforce than educational efficiency and quality efforts alone (Bretell & Ault, 2010).

Instrumentation and Data Collection

The quantitative survey method of data collection was utilized to produce numerical descriptions of the study population needed to answer the research questions (Fowler, 2009). A survey, which used a five-point scale, was used to obtain data for the study. The purpose of the survey was to collect data which can be generalized from a sample to a population so that inferences can be made about the characteristics, attitudes, and behaviors of this population. The questionnaire utilized was the *Science Motivation Questionnaire II* © (SMQII), created in 2011 by Glynn et al. This questionnaire is appropriate for use in research investigating science student motivation and includes criteria students may consider when deciding on an academic major (Glynn et al., 2011). Survey questions conform to the student motivation and perceived success framework by limiting their scope to those criteria identified as constructs of Ajzen's (1991) Theory of Planned Behavior. It was anticipated students would find the range of response options appropriate to the topic questions being asked. It was also anticipated results would show students cite the identifiable factors in their major selection decision-making process (Malgwi et al., 2005). Demographic data on each participant were also collected to provide a framework for the data analysis.

The SMQII consists of a 25-item questionnaire and was converted for online access (Glynn et al., 2011). Glynn et al. (2011) gives permission to educators who wish to use the questionnaire for research and teaching provided they comply with the fair use of this copyrighted and registered work. In order to learn attributes of the sample population which are outside the realm of Glynn's et al. (2011) questionnaire, six questions were included as an addendum to the survey by the researcher, for a total of 31 questions. To preserve validity of the SMQII, the additional six questions were treated as a separate, stand-alone survey during analysis. It was anticipated that the questionnaire would require a time of approximately 15 minutes to be complete by the average survey participant. The questions were based on specific identifiers associated with how college students select their academic major (Glynn et al., 2011).

The SMQII identifies five factors associated with science student major selection: Intrinsic motivation, career motivation, self-determination, self-efficacy, and grade motivation (Glynn et al., 2011). The questions added by the researcher addressed a student's motivational source. Each question was answered with a selection from a five-point scale. The scale limits participant responses across a range enabling the researcher to comparably discern student motivational factors. The limited scaled response options assist the researcher in identifying and analyzing trends in the sample results (Fowler, 2009).

Respondent Demographics

The population of this study was composed of 137 students majoring in biology who attended three higher education institutions in the Midwest. These science students make up a portion of the larger group of STEM students, and their motivations were generalized to describe STEM students. The schools were selected based on their location, size, science degree offerings, and their status as public, private, two-year, and four-year institutions. This was done to ascertain whether student major choice varied among these designations.

A breakdown of the survey results showed 51% of the respondents attended a four-year, public institution. Thirty-one percent of the students in the population were enrolled in a four-year, private institution. The remaining 18% of the responses came from students who attended a two-year, public institution. The majority of the students who participated in the survey, 84% reported their race as White. The remaining 16% of students reported themselves as Black or African-American, Asian, Hispanic or Latino, a combination of two or more races, or none of these. Female respondents made up 68% of the students who responded, while 32% were male. Sixty-nine percent of students surveyed were between the ages of 18 and 34.

Data Analysis

The survey was available to students for four weeks. This time frame was chosen based on the suggestion of the work done by Hamilton (2009). After distributing the survey to students at all three college campuses and giving appropriate response time, completed survey results were downloaded from the survey web site and the data were imported into an Excel file to analyze the results using descriptive analysis.

The type of data gathered in this study was best characterized as ordinal and interval data, based on the definition used by Boone and Boone (2012). The ordinal data were generated by the six questions developed by the researcher to ascertain sources of student motivation to major in science (e.g., family, friends, career, grades). Interval data were produced by using the 25-question survey developed by Glynn et al. (2011) in which multiple questions measuring each motivation type are averaged, producing a composite score for each factor. These composite scores allowed comparison and ranking of motivation types among groups.

Ordinal data analysis. Bluman (2009) identified ordinal data as rankable, but cautioned that precise differences between the ranks do not exist. The central tendency of ordinal data is accurately represented by the median or mode (Boone & Boone, 2012). Summarizing ordinal data by statistical mean would lead to increments between actual survey choices, which are inappropriate for this data set. The purpose of the ordinal data in this study was to discern trends in a student's type and source of motivation when deciding on science as an academic major. Students selected their response to these questions from the choices completing the sentence, *I majored in science because*.

For each of the six sentence completions provided in the survey, the student ranked the source of motivation by choosing one of the following qualifiers: *strongly disagree, disagree, neutral, agree, or strongly agree*. In this study, responses of *agree* and *strongly agree* were considered positive responses for the specific motivational source, while responses of *disagree* and *strongly disagree* were considered negative responses.

Interval data analysis. When the responses to several questions were grouped together for analysis, they were considered interval data that can appropriately be described with the central tendency statistic of a mean (Boone & Boone, 2012). In this study, the responses to the five survey questions for motivation type were averaged, which resulted in a composite score for each motivation type. This process was used for each of the five motivational types (Glynn et al., 2011). Composite scores were averaged for groups of students for the purpose of comparing those groups (e.g. school type, age and sex). Analysis of the data from this study included a percentage comparison of the five possible responses to each question. Observable differences between responses recorded for a question allowed the researcher to ascertain whether the subject of the question influenced the student (positive response), or did not influence the student (negative response).

As noted before, this study adopted Glynn's (2011) composite approach to analyze student response to five motivational factors: intrinsic motivation, grade motivation, career motivation, self-efficacy, and self-determination. The survey consists of five questions for each of the motivation types, for a total of 25 questions. Each question required a response from a five-point scale. The students selected from *never, rarely, sometimes, usually*, and *always* to rank given responses to the statement, *When I am in a college science course*. These responses were converted to numerical values, one for *never*, to five for *always*, to analyze the data generated. Student responses for each of the five questions within a motivational group were averaged to generate a composite score used to characterize that student's overall response to those questions as a group.

Findings from research question 1. The first research question (*What motivation factors are most likely to be reported by students in pursuit of a STEM major?)* was analyzed using descriptive analysis in order to obtain percentages of student responses.

Eighty-nine percent of the biology students who responded to the survey rated *career* as an important factor when making the decision to major in the science related field. The scores for this area were derived from a set of questions which indicated career as a motivation. The five career motivation questionnaire response items each involve the extrinsic motivator of a career, which necessitates learning science as a means to this tangible employment end (Glynn et al., 2011). The five motivation questions regarding career offered to participants discussed having career advantages, would be centered in a science field, would support the participant in a getting a good job as well as determining if science problem solving skills would be utilized in the participants' chosen career. A composite score was garnered from averaging the five questions related to this topic. Students most often chose *usually* or *always* when responding to these questions with an average of the composite scores being a 4.6 on a 5-point scale. Interestingly, only two composite scores fell below the average score of three on the five-point scale in regards to career as a motivation.

Motivation by *grades* obtained in coursework was the second highest factor with 85% of students surveyed responding positively. The scores for this area were derived from a set of questions which indicated grades as a motivation. The five motivation questions regarding the importance of grades to participants discussed the competitive nature of grade perception, the relative importance of achieving a high grade, the overall importance of grades in general, and the particular significance of exam and laboratory grades. A composite score was garnered from averaging the five grade-related questions. The students most often chose *usually* or *always* when responding to these questions with an average of the composite scores being a 4.5 on a 5-point scale. Similar to the above career motivation analysis, only two composite scores fell below the average score of three on the five-point scale in regards to grades as a motivation.

Intrinsic motivation was the third most attributed factor reported by students, with 78% of students surveyed responding positively. The scores for this area were derived from a set of questions highlighting intrinsic factors as motivation. A composite score was garnered from averaging the five intrinsic motivation questions. The five questionnaire response items measuring intrinsic motivation examined the relevancy of science to everyday life, to what extent personal interest came into play, curiosity in science discoveries, the meaningful nature of learning science, and the level of enjoyment experienced while studying science. Students most often chose *usually* or *always* when responding to these questions with an average of the composite scores being a 4.3 on a 5-point scale. Three composite scores fell below the average of three on the five-point scale of intrinsic motivating factors.

Self-efficacy was identified as a motivational factor by 77% of students surveyed. The scores for this area were derived from a set of questions highlighting self-efficacy as factors for motivation. The five self-efficacy measuring questionnaire response items examined the confidence of students to do well in science, the belief of their ability to master knowledge and skills, the belief of achieving good grades on tests and in general, and the positive affirmation that they can understand the subject matter. A composite of the self-efficacy questions resulted in an average score of 4.3. Again, only two composite scores fell below the average of three on the five-point scale measuring intrinsic factors as motivation.

Self-determination, as a motivating factor, was characterized as important by 71% of students surveyed. This factor represents the fewest students choosing *usually* or *always* when answering questions measuring self-determination when compared to the above described factors. The five self-determination measuring questionnaire response items inquired about the adequacy of effort that goes into learning science, the existence of strategies to learn science, the time spent learning science, and the overall preparation and effort required to do well in science. A composite of the self-determination questions resulted in the lowest average score of 4.1. Five composite scores fell below the average of three on the five-point scale assessing self-determination as a motivational factor.

Analysis of participant responses to the six questions added to the survey to measure the source of students' motivation to major in science revealed 16 % of students who responded to the survey concurred with the statement: *I majored in science because a family member majored in science*. Likewise, 17% of students surveyed concurred with the statement: *I majored in science because friends majored in science*. Interestingly, 62% of the students who participated in the survey indicated a teacher motivated them to pursue a science major. Eighty-two percent of the students responded positively to the statement: *I majored in science because I wanted to solve meaningful problems*.

Overall, career, grades, intrinsic, self-efficacy, and self-determination were reported as motivational factors by a majority of science majors participating in this study. Career motivation was rated highest, followed closely by grade motivation. Students reported self-efficacy as tertiary to career and grades when reporting motivational factors in their science major pursuits. Finally, self-determination, while important, was found to be the least attributable factor affecting science motivation. In regards to students' motivation source, few students reported being influenced by friends and family when deciding to major in science. Science students overwhelmingly attributed the desire to solve meaningful problems as central to their decision to major in science. A majority of the students surveyed credited a teacher for influencing their desire to pursue science as a college major.

Findings from research question 2. The second research question (*What differences exist, if any, in the types of motivation factors reported by STEM students from varying types of higher education institutions?)* was analyzed using descriptive statistics in order to obtain percentages of student responses. Responses from the survey were disaggregated by the type of institution biology science majors attended, and their answers were reported by type of institution in order of the highest to lowest composite scores on the survey. The survey questions were analyzed using the instrument developed by Glynn et al. (2011), which used a five-point scale to determine degrees of agreement of whether certain aspects in science courses influenced biology college students' decision to choose this area as their college major. In addition to Glynn's et al. (2011) survey, the researcher added six additional questions to further investigate sources of motivation using the format of a scale. The cultural underpinnings of students attending different institution types may manifest itself as motivational nuances affecting major choice (Porter & Umbach, 2006). Additionally, variation in motivational factors reported by students attending different institution types could lead to retention strategies for students transferring from one institution type to another (President's Council of Advisors on Science and Technology, 2012).

Responses from community colleges. Analysis of the results obtained from students surveyed at a two-year community college found intrinsic motivation and grade motivation were the highest ranked factors with 94% of students answering *usually* or *always* on both the intrinsic motivation and the grade motivation questions. Intrinsic motivation garnered the highest composite score among community college students, with an average composite score of 4.7 for questions measuring intrinsic motivation. There were no composite scores below the average of three on a five-point scale. The average composite score for community college students answering the grade motivation questions on a 5-point scale was 4.6. As with intrinsic motivation, no composite scores fell below the average of three on the five-point scale for questions related to grade motivation.

Both career motivation and self-efficacy questions garnered an 82% *usually* or *always* response rate for community college students. Career motivation had the third highest average composite score for community college students, with a 4.5. Again, no composite scores fell below the average of three on a five-point scale. Community college students ranked self-efficacy fourth out of the five motivational factors. Self-efficacy questions, answered by community college students, resulted in an average composite score of 4.4, with no composite scores below and average of three on a five-point scale.

Finally, the least attributed motivational factor for community college students was self-determination. Self-determination was the lowest ranking motivational factor with 71% of community college students choosing *usually* or *always* for those questions. The average composite score of 4.3 for self-determination was the lowest of all the five motivational factors measured. As in every motivational factor measured for this group, no composite scores were observed below the average of three on a five-point scale.

Community college students, when asked about why they majored in science, identified the desire *to solve meaningful problems* to a high degree, with 94% of students surveyed responding positively. Only 23% of community college students indicated a friend had influenced them to major in science. Interestingly, the lowest ranked source of motivation for community college students was family. Only 12% of community college students surveyed revealed they majored in science due to the influence of a family member.

In summary, community college students reported intrinsic and grade motivations highest, followed by career and self-efficacy, and finally self-determination factors lowest. It should be noted that while the composite scores for community college students did fall in a certain rank, each of the five motivational factors were rated with no composite scores falling below an average of three on the five-point scale for any of the five motivational areas. While self-determination was the lowest ranked of the five factors, it was still ranked high, with 71% of surveyed community college students ranking this category favorable. While friends and family appear not to be influences to community college students on major choice, teachers and the desire to solve meaningful problems do appear to influence student major choice in the sciences.

Response from four-year private universities. Analysis of the results obtained from students surveyed at a four-year, private institution revealed *grade motivation* as the highest ranked motivational factor, with an average composite score of 4.6 on the five-point scale. Eighty-six percent of four-year public university students surveyed answered *usually* or *always* for questions pertaining to grade motivation. None of the composite scores for grade motivation fell below an average of three on a five-point scale.

Career motivation was the second highest ranked motivating factor reported by four-year private university students. An average composite score of 4.5 out of five on the scale was calculated for this group when answering questing pertaining to career motivation. While two composite scores fell below an average of three on the five-point scale, a total of 84% of private four-year university students responded positively to questions measuring career motivation.

Self-efficacy ranked third among the five motivational types among private four-year university students. The average composite score for this group was 4.1 out of 5 on the scale for questions measuring student self-efficacy. While one average composite score fell below three on the five-point scale, 65% of students surveyed responded positively to questions revealing self-efficacy as a motivational factor.

Just over half (58%) of the private four-year university students surveyed reported intrinsic motivation as an important factor in their science pursuit. Intrinsic motivation ranked fourth out of the five motivational factors measured in private four-year university students, garnering an average composite score of 4.0 out of 5 on the scale. Two composite scores in this group fell below an average of 3 on this scale.

The least attributed motivational factor reported by private four-year university students was self-determination. Analysis of composite scores for self-determination measuring questions revealed an average of 3.9 out of five on the scale. Four composite scores in this group fell below an average of three on the five-point scale. Sixty-five percent of private four-year university students did respond positively to the self-determination measuring questions.

Private four-year university students, when asked why they majored in science, identified the desire to *solve meaningful problems* to a high degree, with 81% of students surveyed responding positively. Fifty-three percent of these students reported they were influenced by a teacher to major in science. Only 21% of private four-year university students indicated a friend had influenced them to major in science. Finally, the lowest ranked source of motivation for private four-year university students was family. Only 12% of these students surveyed revealed they majored in science due to the influence of a family member.

Response from four-year public universities. Analysis of the results obtained from students surveyed at a four-year, public institution revealed *career motivation* as the highest ranked motivational factor with an average composite score of 4.7 on the five-point scale. Ninety-five percent of four-year public university students surveyed answered *usually* or *always* for questions pertaining to grade motivation. As was found in the other institution types studied, none of the composite scores for grade motivation fell below an average of three on a five-point scale.

Four-year public university students responded to intrinsic motivation and grade motivation questions similarly; both these motivational types garnered an average composite score of 4.5 on a 5 point scale. Eighty-seven percent of public four-year university students surveyed ranked intrinsic motivation question as *usually* or *always* influencing their science efforts. Seven composite scores for intrinsic motivation fell below an average of 3 on the 5-point scale. Grade motivation questions garnered an 83% positive response rate from public four-year university students, with 10 composite scores falling below the average of 3 on the 5-point scale.

The average composite score for public four-year university students for self-efficacy motivational factors was 4.3. Self-efficacy was the third most cited motivational factor for this group. Eight-four percent of the average composite scores for self-efficacy represented a positive response by these four-year public university students. Nine of the average composite scores for self-efficacy fell below the average of 3 on the 5-point scale.

The lowest ranking motivational factor for four-year public university students surveyed was self-determination. Self-determination as a motivational factor garnered an average composite score of 4.2 for these students. Seventy-six percent of the four-year public university students surveyed ranked self-determination positively, fewer than any of the other four motivational factors above.

Public four-year university students, when asked why they majored in science, identified the desire to *solve meaningful problems* to a high degree, with 82% of students surveyed responding positively. Forty-five percent of these students reported they were influenced by a teacher to major in science. Only 16% of public four-year university students indicated a family member had influenced them to major in science. Interestingly, the lowest ranked source of motivation for public four-year university students was friends.

Summary of responses from types of institutions. Community college students report *intrinsic* and *grade motivations* highest, followed by career and self-efficacy, and finally self-determination factors lowest. While two-year community college and four-year private university biology students responded grades were a high motivation for them; this factor was not the highest response for four-year public university biology students who participated in the survey. Analysis of the results obtained from students surveyed at a four-year public university were as follows: The highest ranking factor was career motivation with 86% of surveyed students answering *usually* or *always* to questions measuring career motivation. Career motivation followed with 83% of surveyed students responding in this way. Survey questions framed around the characteristics of self-determination were responded to positively (*usually* or *always* responses) by 65% of surveyed, four-year public university students. The results obtained by students surveyed answering the self-efficacy framed questions were the same as those obtained for the self-determination questions with a 65% positive response rate from surveyed students. Survey questions measuring intrinsic motivation showed the lowest positive response rate (58%) by four-year public university students. Four-year public university student motivation type responses can be summarized from highest to lowest as follows: grade, career, self-determination, and self-efficacy (equally), and finally, intrinsic motivation.

The influence a family member has on a student deciding to major in science was analyzed by disaggregating the survey data by type of institution. The responses to whether family members influenced their choice to major in science were similar regardless of institution type. When asked whether family members influenced their decision to major in science, only 16% of four-year public university students surveyed and 16% of four-year private university students surveyed responded positively. Similarly, only 12% of two-year public community college students surveyed responded positively. When asked whether friends influenced a student's decision to major in science, only 13% of four-year public university students surveyed responded positively, 24% of two-year public community college students surveyed responded positively, and 21% of four-year private university students surveyed responded positively.

Teacher influence, job prospects and *solving meaningful problems* were reported by students surveyed as factors influencing their decision to major in science. A higher percentage of two-year public community college students reported being influenced by a teacher to major in science (59%) compared to 53% of four-year private university students, and only 45% of four-year public university students surveyed. Four-year private university students had the highest percentage (84%) of those surveyed responding positively to the statement, *I majored in science because I wanted to get a good job*, compared to 71% and 73% of students surveyed at a two-year public community college and a four-year public university, respectively. When asked whether they majored in science because they wanted to solve meaningful problems, 94% of two-year public community college students surveyed responded positively, compared to 86% of four-year private university students and 82% of four-year public university students.

Findings from research question 3. The third research question (*What differences exist, if any in the types of motivation factors reported by STEM students as disaggregated by age and sex?*) was analyzed using descriptive statistics in order to obtain percentages of student responses. In research question three, responses from the survey were disaggregated by age and sex. Findings are reported below in order of the highest to lowest composite scores for each motivation factor measured by the survey. As for Research Question One and Research Question Two, survey questions were analyzed using the instrument developed by Glynn et al. (2011), which used a 5-point scale to determine degrees of agreement of whether certain aspects in science courses influenced biology college students' decision to choose this area as their college major. In addition to Glynn's et al. (2011) survey, the researcher added six additional questions to further investigate sources of motivation using the format of a scale.

Response from males. *Grade motivation* and *self-efficacy* were the highest ranked motivational factors reported by males. Both grade motivation and self-efficacy garnered a composite score of 4.4 on a five-point scale. This composite score reflects a 77% positive response by males answering questions measuring grade motivation and self-efficacy separately. Only one grade motivation composite score fell below the average of 3 on a five-point scale, while no self-efficacy composite scores fell below this average of 3.

Career motivation ranked third among males surveyed. The composite score for males answering career motivation questions was 4.3, just below grade motivation and self-efficacy. Seventy-one percent of males surveyed responded with *usually* or *always* when rating the importance of career in determining their college major. Two composite scores fell below a 3 on a 5-point scale for males answering career motivation questions.

The composite score garnered for males answering questions measuring intrinsic motivation was 4.2. Sixty-nine percent of males regarded intrinsic motivation as positive by answering *usually* or *always* when rating intrinsic motivating factors. One composite score fell below the average of 3 on a 5-point scale for intrinsic motivation. Intrinsic motivation ranked fourth out of the five motivational factors measured.

Finally, males rated self-determination lowest among the motivational factors, with 57% responding positively to those questions. The average composite score for males answering self-determination questions was 3.9 out of 5 on the scale. While this factor was ranked the lowest of the five motivational factors, it should be noted that most males rated self-determination as important in their STEM major coursework. Only two composite scores for this area fell below the average of 3 on the 5-point scale.

When asked why students chose a major in science, 80% of males surveyed attributed their decision to the desire to get a good job. Only 9% of males surveyed attributed their science major choice to a family members influence. Seventy-four percent of males surveyed chose *to solve meaningful problems* when asked why they majored in science. Friends and teachers were attributed by 27% and 37% of males surveyed, respectively.

Response from females. *Career motivation* was the highest rated of the five motivational factors measured for females surveyed. The composite score for females answering career motivation questions was 4.7 on a 5-point scale. This high composite score was the result of 96% of females surveyed rating career motivation positively. Three composite scores did fall below the average of 3 on the 5-point scale.

Grade motivation ranked second for females surveyed. Grade motivation garnered a composite score of 4.6 on the 5-point scale, with only one score falling below 3 on the scale. Ninety percent of females surveyed answered grade motivation questions with *usually* or *always* important for their major coursework.

Intrinsic motivation was the third most attributed motivational factor for females surveyed. Females answering questions measuring intrinsic motivation resulted in a composite score of 4.4 on the 5-point scale. Eighty-three percent of females surveyed reported intrinsic motivating factors as important for their college major. Two composite scores fell below the average of 3 on the 5-point scale.

Females surveyed responded positively to self-determination and self-efficacy questions nearly equally with a resulting composite score of 4.2 for both motivational groups. Self-determination questions garnered a positive response from 78% of females surveyed. Self-efficacy questions followed with a 76% positive response from females surveyed. Three composite scores fell below an average of 3 on the 5-point scale for self-determination, while only two fell below this level for self-efficacy questions. Self-determination and self-efficacy ranked 4th and 5th, respectively among females out of the five motivational types measured.

When asked why students chose a major in science, 88% of females surveyed attributed their decision to major in science to a desire solve meaningful problems. Only 19% of females surveyed attributed their science major choice to a family members influence. Seventy-four percent of females surveyed cited future job attainment desires as a reason for their science major choice. Friends and teachers were attributed by 15% and 56% of females surveyed, respectively.

Age 21 and under responses. The highest rated motivational factors students surveyed age 21 or under were *career* and *grade motivation*. The respondents in this age group answered career and grade motivation questions with a resulting 4.6 average composite score for both these motivational types. Ninety-one percent of students surveyed age 21 and under rated career motivation positively, with either *usually* or *always i*mportant in their major coursework. Three composite scores in this group fell below the average of 3 on a 5-point scale. Eighty-eight percent of those surveyed answered grade motivation questions as important in their field of study.

Self-efficacy and intrinsic motivational factors both garnered an average composite score of 4.2 on a 5-point scale among students surveyed age 21 and under. Seventy-six percent of surveyed students 21 and under cited self-efficacy as *usually* or *always* important in their science coursework, with two composite scores falling below 3 on a 5-point scale. Intrinsic motivation questions were answered positively by 71% of students surveyed 21 years of age and under. Three composite scores fell below 3 on a 5-point scale for this age group when answering intrinsic motivation questions.

Self-determination ranked 5th out of the five motivational factors measured for students surveyed age 21 and under. Self-determination, for this group garnered an average composite score of 4.1 on a 5-point scale. Even though self-determination was the lowest rated factor for this group, 72% of students surveyed responded positively to self-determination measuring questions. Four composite scores did fall below the average of 3 on a 5-point scale for self-determination in this group.

When answering questions regarding a student's source of motivation to major in science, 84% those age 21 or under cited the desire to solve meaningful problems. Seventy-eight percent of surveyed students age 21 or under expressed the desire to get a good job was influential in their major choice decision. Interestingly, only 20% of these students attributed their decision to major in science to the influence of a friend or family member. Teachers were attributed by 55% of students surveyed age 21 or under, as influential in that students decision to major in science.

Age 22 through 34 responses. Analysis of the results obtained from students surveyed age 22 through 34 revealed *intrinsic motivation* as the highest ranked motivational factor for this group. Ninety-six percent of students surveyed in this age group responded positively to questions measuring intrinsic motivation. This group garnered an average composite score of 4.7 for intrinsic motivation questions. No composite scores fell below an average of 3 on a 5-point scale for intrinsic motivation.

Career motivation ranked second for this group. Surveyed students between the ages of 22 and 34 responded to career motivation questions positively at a rate of 88% when answering questions gauging the importance of career in their science major pursuit. The average composite score for these students for all career motivation questions was 4.6 on a 5-point scale. There were no composite scores for career motivation in this age group below an average of 3 on the 5-point scale.

Grade motivation for this age group followed career motivation with the slightly lower composite score of 4.5 on the 5-point scale. Eighty percent of students surveyed between the ages of 22 and 34 affirmed grade motivation was an important aspect of their major choice. Only one grade motivation composite score fell below the average of 3 on a 5-point scale for this group. Grade motivation was followed closely by self-efficacy for those surveyed in the age group of 22-34 years old.

Self-efficacy, for the 22-34 years old age group, garnered a composite score of 4.4 on the 5-point scale. No composite scores fell below an average of 3 on the 5-point scale for this group. Students in this group responded to self-efficacy survey questions with an 80% positive response rate. While this is the same positive response rate observed for this group on grade motivation questions, the slightly lower average composite score aligns self-efficacy just below grade motivation for those surveyed 22-24 years old.

Finally, self-determination garnered the lowest composite score for the 22-34 age group. Self-determination was affirmed by students surveyed as important in their science study field, but the observed 4.3 average composite score ranked this motivation type 5th among the five motivational types measured for this study. Seventy-six percent of surveyed students between the ages of 22 and 34 answered questions measuring self-determination with a *usually* or *always* importance rating.

When asked why students decided to major in science, 88 % surveyed in the age 22-34 years old group responded with the selection: *I wanted to solve meaningful problems*. Eighty percent of those surveyed in this age group cited the desire to get a good job as a source of their major choice decision. Only 4% of these students attributed their science major choice to a friend or family member. A teacher was attributed by 36% of students age 22-34 as influencing their science major choice.

Age 35 and over responses. *Intrinsic motivation* was observed to be the highest ranked motivational factor for students surveyed age 35 or over. All students surveyed in this age group responded positively to questions measuring intrinsic motivation. An average composite score of 4.5 was observed for this group when answering questions measuring intrinsic motivation. No composite scores fell below an average of 3 on the 5-point scale.

The motivational factor receiving the second rank for this age group was self-efficacy. Self-efficacy garnered a 60% positive response rate among the 35 years old and above group. The average composite score for questions measuring student self-efficacy was 4.2 on the 5-point scale. Self-efficacy was closely followed by grade motivation for this group.

Grade motivation garnered an average composite score of 4.2 for those surveyed age 35 and above. Sixty percent of those surveyed answered grade motivation positively by choosing the survey responses of usually or *always* when relating the importance of grades in their coursework. One composite score was observed below an average of 3 on the 5-point scale for this group answering grade motivation questions. It should be noted, while grade motivation received the same positive response rate as self-efficacy above, the slightly lower average composite score for grade motivation ranks grade motivation for this age group as 3rd.

Career motivation, like grade motivation and self-efficacy, garnered a 60% positive response rate for students surveyed age 35 and above. The lower average composite score of 4.0 placed career motivation below those described previously for this group. No average composite scores fell below an average of 3 on the 5-point scale for this group answering questions measuring career motivation. Career motivation ranked 4th among the five motivations factors measured for students age 34 and above.

The lowest ranking motivational type for the 34 and above age group was self-determination. Only 40% of those students surveyed in this age group answered survey questions measuring self-efficacy positively. The average composite score for students surveyed age 35 and above was 3.8 on the 5-point scale when answering questions measuring self-determination as important for their science coursework. While self-determination was the lowest ranked of the five measured motivational factors for this study, self-determination was affirmed as important for these students in their science classes. No average composite scores fell below 3 on the 5-point scale.

Only 40% of those surveyed in the 35 years old and greater age category responded positively to friends, teachers, or potential jobs as influencers in their decision to major in science. Interestingly, none of those surveyed in this age category attributed family members as being an influence for majoring in science. Eighty percent of those 35 and over in age attributed their grades in science as influencing their decision to major in science. Sixty percent of those surveyed in this age category attributed the desire to solve meaningful problems as influential in their decision to major in science.

Differences were observed in the motivational types and sources of motivation between the groups studied. Males rated grade motivation and self-efficacy highest, while females rated career motivation highest and self-efficacy lowest. Both males and females surveyed reported friends and family had little influence on their decision to major in science. Both males and females attributed their desire to solve meaningful problems as an influence in their major choice.

The students surveyed belonging to the 22-34 age group ranked intrinsic motivation highest and self-determination lowest among the five motivational types studied. Career and grade motivation was highest in the students in the 21 years of age and under group. Like the age 22-34 group, the 21 years of age and under group rated self-determination lowest. All age groups reported the desire to solve meaningful problems as influencing their science major choice. Friends and family were reported as not important among those surveyed less than 21 to 34 years of age, while friends did appear to influence those students older than age 34.

Summary

This quantitative survey study collected information on student motivational type and source relating to how students decide on their academic major in biology. The data obtained were analyzed to further the understanding of the motivational factors used by students when deciding on a science major. The goal of this study was to provide the data necessary for the development of initiatives that increase the number of students majoring in STEM academic areas, and improve retention of existing student majors.

Career, grade, intrinsic, self-efficacy, and self-determination were reported as motivational factors by a majority of science majors participating in this study. Few students reported being influenced by friends and family when deciding to major in science. Science students overwhelmingly attributed the desire to solve meaningful problems as central to their decision to major in science. A majority of students surveyed credited a teacher for influencing their desire to pursue science as a college major.

Community college students reported intrinsic and grade motivations highest, followed by career and self-efficacy, and finally self-determination factors lowest. While two-year community college and four-year private university biology students responded grades were a high motivation for them, this factor was not the highest response for four-year public university biology students who participated in the survey. Four-year public university student motivation type responses were summarized from highest to lowest as follows: grade, career, self-determination and self-efficacy (equally), and finally intrinsic motivation. The responses to whether family members influenced their choice to major in science were similar regardless of institution type. When asked whether friends influenced a student's decision to major in science, only 13% of four-year public university students surveyed responded positively, 24% of two-year community college students surveyed responded positively, and 21% of four-year private university students surveyed responded positively.

Teacher influence, job prospects, and *solving meaningful problems* were reported by students surveyed as factors influencing their decision to major in science. Four-year private university students had the highest percentage (84%) of those surveyed responding positively to the statement: *I majored in science because I wanted to get a good job*. When asked whether they majored in science because they wanted to solve meaningful problems, 94% of two-year public community college students surveyed responded positively, compared to 86% of four-year private university students, and 82% of four-year public university students.

Males rated grade motivation and self-efficacy highest, while female students rated career motivation highest and self-efficacy lowest. Both males and females reported friends and family had little influence on their decision to major in science. Both males and females attributed their desire to solve meaningful problems as an influence in their major choice. Students age 22-34 ranked intrinsic motivation highest and self-determination lowest among the five motivational types studied. Career and grade motivation was highest in the students age 21 and under. Like the older group, this younger group rated self-determination lowest. All age groups reported the desire to solve meaningful problems as influencing their science major choice

Chapter Five will provide the summary and conclusions drawn by the researcher based on the findings. The implications deduced from the conclusions will be related to problems identified by the literature in Chapter Two. Following the implications for practice discussion, the researcher will offer recommendations for future research. Future research recommendations will be centered on the subjects of research design, population and sample, and instrumentation.

Chapter Five: Summary and Conclusions

The United States currently ranks 21st in 9th grade science literacy, while Finland, Hong-Kong, Japan, New Zealand, Canada, Estonia, Australia, Netherlands, and Taiwan take the top 10 spots (Organisation for Economic Co-Operation and Development [OECD], 2010). Atkinson and Mayo (2010) emphasized the United States education system does not graduate adequate numbers of STEM majors to fill jobs in key fields. A report by the NEC et al. (2011) predicted America's future economic growth and competitiveness will largely be dependent upon skills developed in STEM educational fields. The NEC (2011) report summarized the need for improvement in the results of American science education by increasing the number and quality of American higher education graduates adequately prepared for the demands required by globally competitive employers (Atkinson & Mayo, 2010). Efforts to improve and expand America's scientific competencies continue in the form of a comprehensive approach reaching into the combined areas of STEM (NEC, 2011). The American Competitiveness Initiative was created in 2006 to improve America's global economic competitiveness by increasing funding for STEM education areas. Presidential actions have also attempted to spur STEM change. The President's Council of Advisors on Science and Technology (2012) emphasized the breadth of desired change by calling on educators to focus on both preparation and inspiration of students.

Chapter Five will reiterate the predominant aspects of the study. The findings detailed in Chapter Four will be summarized. A discussion of the conclusions drawn from these findings, with support from related literature, follows. The remainder of the chapter details suggestions for addressing the issues raised during the research and offers recommendations for any future research related to the theme of this study.

Review of the Study

The purpose of this research study was to ascertain the reasons why students choose a STEM major and to determine what decision criteria influenced this decision. According to the TPB proposed by Ajzen (1991), the components observed in decision-making can be quantified and analyzed as predictors of behavior. Information collected during this study was accomplished through the use of a 25-question survey developed and validated by Glynn et al. (2011) and a six-question survey developed by the researcher. The SMQII identified five factors associated with science student major selection: intrinsic motivation, career motivation, self-determination, self-efficacy, and grade motivation (Glynn et al., 2011). The questions added by the researcher addressed a student's motivational source. Each question was answered with a selection from a five-point scale.

The population of this study included students majoring in biology at three higher education institutions in the Midwest; one two-year public community college, one four-year public university, and one four-year private university. After distributing the survey to students at all three college campuses and giving appropriate response time (Hamilton, 2009), completed survey results were downloaded from the survey web site, and the data were imported into an Excel file to analyze the results using descriptive analysis (Creswell, 2009).

Two types of data were analyzed in this study; ordinal data and interval data (Boone & Boone, 2012). The ordinal data were generated by six questions developed by the researcher to ascertain sources of student motivation to major in science (e.g., family, friends, career, grades) Interval data were produced by using the 25-question survey developed by Glynn et al. (2011) in which multiple questions measuring each motivation type were averaged, producing a composite score for each factor. These composite scores allowed comparison and ranking of motivation types among groups. Intrinsic motivation questions use the terms, “interesting, meaningful, curious, and enjoy” when describing a student’s participation in science coursework. Grade motivation questions encompassed the importance of grades to a student. Self-determination was gauged with questions using the terms, “effort, strategies, time preparing, and study.” Career motivation questions employed terms relating to jobs and potential earnings as motivators. Self-efficacy questions utilized words, such as “confident, believe, and sure” when relating classroom experiences.

Findings

The first research question (*What motivation factors are most likely to be reported by students in pursuit of a STEM major?)* was examined by averaging the responses from the five survey questions for each of the motivational types to produce a single composite score for each motivational type (Boone & Boone, 2012; Glynn et al., 2011). Eighty-nine percent of the students who responded to the survey rated career as a factor when making the decision to major in the science related field. Being motivated by grades obtained in coursework was the second highest factor with 85% of students surveyed responding positively. Intrinsic motivation was the third most attributed factor reported by students, with 78% of students surveyed responding positively. Self-efficacy was identified as a motivational factor by 77% of students surveyed. Self-determination, as a motivating factor, was characterized as important by 71% of students surveyed.

A limited number of students reported being influenced by friends and family when deciding to major in science. Students overwhelmingly attributed the desire to solve meaningful problems as central to their decision to major in science. A majority of students surveyed credited a teacher for influencing their desire to pursue science as a college major.

The second research question (*What differences exist, if any, in the types of motivation factors reported by STEM students from varying types of higher education institutions?)* was examined by averaging the responses from the five questions for each motivational type to produce a composite score for each motivational type, then disaggregating these data by institution type. Community college students reported intrinsic and grade motivations highest, followed by career and self-efficacy, and finally self-determination factors lowest. It should be noted that while the composite scores for community college students did fall in a certain rank, each of the five motivational factors were rated with no composite scores falling below an average of three on the five-point scale for any of the five motivational areas. While self-determination was the lowest ranked of the five factors, it was still ranked high with 71% of surveyed community college students ranking this category favorable. Friends and family appeared not to be influences to community college students on their choice to select science as an academic major; however, teachers and the desire to solve meaningful problems did appear to influence student major choice in the sciences.

Students surveyed at a four-year, private institution revealed grade motivation as the highest ranked motivational factor. Career motivation was the second highest ranked motivating factor reported by four-year private university students. Self-efficacy ranked third among the five motivational types among private four-year university students. Fifty-eight percent of private four-year university students surveyed reported intrinsic motivation as an important factor in their science pursuit. Intrinsic motivation ranked fourth out of the five motivational factors measured in private four-year university students. The least attributed motivational factor reported by private four-year university students was self-determination. As detailed earlier, self-determination was gauged with questions using the terms, "effort, strategies, time preparing, and study." These students were motivated to *solve meaningful problems* and were influenced by teachers but were not motivated by friends or family.

Students surveyed at a four-year, public institution revealed career motivation as the highest ranked motivational factor. Four-year public university students responded to intrinsic motivation and grade motivation questions similarly. Self-efficacy was the third most cited motivational factor for this group. The lowest ranking motivational factor for four-year public university students surveyed was self-determination.

The third research question (*What differences exist, if any in the types of motivation factors reported by STEM students as disaggregated by age and sex?)* was examined by averaging the responses from the five questions for each motivational type to produce a composite score for each motivational type, then disaggregating this data by age and sex. Differences were observed in the motivational types and sources of motivation between the groups studied. Males rated grade motivation and self-efficacy highest, while females rated career motivation highest and self-efficacy lowest. Both males and females surveyed reported friends and family had little influence on their decision to major in science. In addition, both males and females attributed their desire to solve meaningful problems as an influence in their major choice.

Students whose age fell in the age group of 22-34 ranked intrinsic motivation highest and self-determination lowest among the 5 motivational types studied. Career and grade motivation was highest in students whose age fell in the age group of 21 and under. Like the students whose age fell in the age group of 22-34, the students surveyed who fell in the 21 years of age and under group rated self-determination lowest. All age groups reported the desire to solve meaningful problems as influencing their science major choice. Friends and family were reported as not important among those surveyed less than 21 to 34 years of age, while friends did appear to influence those students surveyed age 34 and above.

Conclusions

Science students surveyed at public two-year colleges, public four-year universities, and private four-year universities chose a major in science because they were influenced by a teacher and possessed the desire to solve meaningful problems. While students taking part in this survey often rank the five motivational types studied as important in their science major pursuit, these students rank career motivation above all others. Previous research has shown students entering STEM majors are frequently doing so to achieve planned careers in STEM fields (Gasiewski et al., 2012). When deciding to major in science, students surveyed did not report being influenced by friends or family. With the emphasis placed on STEM careers by high school guidance counselors and the media, along with economic factors, current students may have been recruited or selected as a result of these efforts (Atkinson & Mayo, 2010; National Science Board, 2010; Sharkness, Jr, Hurtado, Figueroa, & Chang, 2011). Students surveyed may have been less influenced by friends and family due to the unavailability of jobs in the geographic region of this study pertaining to science fields. It is the opinion of the researcher that science students have deeply held career objectives that may transcend parental advice. Interest in science in an area lacking science jobs may attract students intent on adventuring beyond their family experience (Atkinson & Mayo, 2010).

The second research question required disaggregating obtained data by institution type. A comparison of student responses from different institution types revealed differences in student responses between these institutions. For example, public two-year college students reported intrinsic motivations highest when compared to other institution types. Intrinsic motivation was measured with questions gauging a student's personal interest, curiosity, and enjoyment in science. It was interesting for the researcher to observe these traits of curiosity and enjoyment present in community college students at a level higher than observed within other institution types.

Many students attend community college to develop their interests and learn about themselves prior to deciding on a major (Goldrick-Rab, 2010). By comparison, four-year private university students rated intrinsic motivations lowest when surveyed. Four-year private university students rated grade motivations highest among the five motivations studied. This dichotomy between community college and private university student motivations was noteworthy in the opinion of the researcher. Relatedly, public university students ranked career motivation as highest among the five motivations studied. This information could be instructive at a time when smoothing the transition from community college to four-year universities is increasingly sought (Dowd, 2012). While it is beyond the scope of this research, it is contemplative whether students were influenced by the culture of the institution they attended to revere some motivational characteristics over others. Alternatively, students with differing motivations may be attracted to different institution types. This subject will be discussed further in the recommendations for future research section.

When disaggregated by sex, analysis of the data generated by the survey allowed the researcher to observe motivational variations when comparing males and females. While career and grade motivations were high among both males and females surveyed, the source of their motivation varied. Females were less likely to be influenced by a family member to major in science when compared to males. Females are less likely than males to major in STEM fields, in part due to departmental cultures at academic institutions (Hill, Corbett, & St. Rose, 2010). Males' sources of motivation was predominately career related, compared to females' desire to solve meaningful problems. While family influence rated relatively low for both males and females, an interesting observation of the evidence notes females received less family influence toward their major choice than male students. Parental encouragement plays a significant role in students pursuit of career goals (Dietrich & Salmela-Aro, 2013) Equally interesting was the difference observed between male student and female student primary sources of motivation. Female motivation sources were of a more intrinsic nature, compared to the extrinsic nature of male's sources of motivation, comparatively. Improving the work-life balance policies at educational institutions could bring the culture change needed to attract more females to STEM academics (Hill et al., 2010).

The third research question also required the disaggregation of the data into age groups of those surveyed. Survey participants whose age was within the 21 years of age and under group rated career and grade motivations highest as it related to their science major choice, while intrinsic motivations rated higher for those students whose age places them in the 22 years of age and above group. Prior to this research, it was the opinion of the researcher that students 22 years of age and above group might be more career motivated, assuming they were returning to school after job displacement. Lips and McNeil (2009) articulated: "American students may be less prepared to compete for jobs in STEM fields than students with degrees from other countries" (p. 3). The researcher offers that these older students may be returning to school to follow their interests following an unsatisfactory or unfulfilling career.

In *Rising Above the Gathering Storm*, a report by the National Research Council published in 2007, an observation is made regarding the importance of the government supporting the retraining of displaced science and engineering workers as a step to keeping pace with the increased pace of technological innovation. Life-long learning is identified in this report as a necessity to be promoted by employers for workers as technology companies strive for a larger global market-share (NRC, 2007). As stated earlier, students surveyed generally did not rate family and friend influences as particularly important, but it is important to note that the older students surveyed did show a higher influence from friends of any other group. This may be in part due to the experience an older student may have with interacting with professional contemporaries. Students whose age places them in the 22 years of age and above group may be more likely to have been influenced by friends they consider "successful" in their careers and have made a conscious decision to follow their example. Younger students may not have many friends currently in science career fields due to their traditional (immediately after high school) college entry timing.

Implications for Practice

Findings from this study contribute to a greater understanding of student motivations surrounding science major choice. Knowledge of the motivations influencing students choosing a major in STEM field provides the insight needed to cultivate a larger participation in these educational areas. The number of graduates in these academic fields has been on the decline in the United States since the 1960s, which, according to Lips and McNeil (2009), results in a diminished ability of the United States to compete in science and engineering on the world stage.

Despite the United States government efforts to improve America's STEM proficiencies, measurable improvement has not been achieved on a wide scale (National Academy of Sciences et al., 2010). In the *Gathering Storm* report (2005) America's preeminence in STEM innovation was described as faltering. The *Gathering Storm* report (2005) led to a government stimulus in the form of The America COMPETES Act (2007), which called for the implementation of many of the recommendations of the 2005 *Gathering Storm* report. In 2010, the National Academy of Sciences et al. released a report on the progress made toward America's competitiveness in the global marketplace which noted that it was "he unanimous view of the committee members participating in the preparation of this report is that our nation's outlook [had] worsened" (p. 5).

Findings from this study could play a role in reforming science instruction towards development of a pedagogical flexibility conducive of greater student retention and success, while informing processes aimed at increasing the number of students entering STEM majors (Ewell et al., 2003). Examination of the motivations displayed in science courses are broad and sometimes divergent among the groups studied. Hong and Shull (2010) found students often cited poor instruction in their courses and lack of supportive faculty as reason STEM students discontinue their pursuit of a STEM major. Evidence from this study supports the idea that teacher influence is a positive motivational factor cited by students surveyed.

Instruction that is informed by the findings of this study would develop student proficiencies through varying objectives designed to appeal to the range of motivations reported by students in their classes. Given the influence a teacher possesses in the development of subject matter interest in students, teachers successful in engaging students should be identified, and their practices, and classroom management experience shared with other teachers (Osborne et al., 2003). Creating learning communities where collaboration between teachers is constant can lead to an expansion of the capacity of teachers to achieve student engagement (Campbell et al., 2012). Exercises that focused on solving real world problems would seem to be of interest to the majority of the students surveyed as a part of this study.

Foster (2010) contended that those best suited to bring meaningful activities into the math and science classroom may not be teachers. Retired non-teaching STEM professionals, with a wealth of real-world experience, could bring the needed expertise into the classroom (Foster, 2010). The National Governors Association (2007) recommended changing the way K-12 STEM teachers are hired. The report, *Building a Science, Technology, Engineering, and Math Agenda*, speculated teacher education and certification programs should be modified to allow experienced STEM professionals who do not have teaching credentials to gain those credentials while in the classroom (Toulmin & Groome, 2007).

Tobias (1990) emphasized the need for change in introductory college coursework to provide better insight and encouragement to students interested in professions in STEM fields. Students often choose their major early in their college career when they are taking introductory courses with a relatively high dropout rate, based on mastery of material not entirely indicative of the skills needed in the workplace (Drew, 2011; Howe & Burnaby, 2005; Osborne et al., 2003; Tobias, 1990). It is the opinion of the researcher that workplace skills and educational objectives should merge together in classrooms of the future. The NEC et al. in 2011, published the report, A *Strategy for American Innovation: Securing Our Economic Growth and Prosperity.* This report emphasized educational investments and workforce training as essential building blocks for a workforce which creates new ideas (NEC et al., 2011).

Increasing the participation of underrepresented groups in the STEM workforce requires increasing members of those underrepresented groups in the educational system (Atkinson & Mayo, 2010). The President's Council of Advisors on Science and Technology (2012) found women and racial minorities constitute approximately 70% of college students and only earn 45% of the STEM degrees. In the 2012 President's Council of Advisors on Science and Technology report, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics,* women and minorities are described as encountering an academic culture in STEM fields that can be unwelcoming nor attuned to their needs or perspectives. Underrepresentation of certain demographic groups in STEM education and careers is a result of members of these demographic groups deciding not to major in STEM areas (Atkinson & Mayo, 2010). Ajzen's (1991) TPB explained this decision behavior by maintaining that people who are led to believe they have neither the means, nor the opportunities to participate in a particular activity are not likely to form the intentions to engage in that activity.

Researchers conclude women and minorities have not chosen STEM education, not due to a lack of interest, but rather from the lack of role models to whom they can identify with and be mentored by (Lips & McNeill, 2009; Page et al., 2009). Applying Ajzen's (1991) theory, mentors and role models can provide the encouragement missing from those individuals of underrepresented STEM groups leading to individual intention to pursue and engage in the activity (Ajzen, 1991). The results of this research provided data identifying female students majoring in biology were highly motivated, but followed behind males, when reporting encouraging influence from friends and family.

Formal mentoring programs may provide needed support for underrepresented groups. In a 2009 outreach effort by California Institute of Technology and City College of San Francisco's Computer Networking and Information Technology (CNIT) program, an increase of female student participation by 12 % was recorded the first year and again by 15 % the second year of the initiative (Milgram, 2011). Atkinson and Mayo (2010) observed, "the goal of STEM education… should be to produce the best STEM graduates to fuel the innovation economy, regardless of ethnicity or socio-economic status" (p. 85).

Recommendations for Future Research

This study was designed to gather motivation data of science student major choice criteria. A review of the literature at the onset of this study revealed few studies on the decision-making process students employ when deciding on a college major. One study focused on the success of students majoring in accounting (Tan & Laswad, 2009). Another investigated reasons for low retention and persistence within a group of engineering majors (Budny et al., 2010). While a great deal has been written on the need to encourage participation in STEM academic majors, little has been published on the motivations leading students to major in a STEM field.

This study was conducted through the use of a previously published questionnaire. The questionnaire utilized was the *Science Motivation Questionnaire II* © 2011 by Shawn M. Glynn (SMQII). Survey questions conformed to the student motivation and perceived success framework by limiting their scope to those criteria identified as constructs of Ajzen's (1991) TPB. The SMQII contains questions designed to measure a participants reliance on five motivational types: grade motivation, career motivation, intrinsic motivation, self-determination, and self-efficacy. This questionnaire has been validated for use in research investigating the motivation of science students and includes specific criteria students may contemplate when deciding on an academic major (Glynn et al., 2011). The following sections discuss potential alterations of this study with potential outcomes.

Research design. The study utilized a survey designed to collect quantitative results from participants majoring in biology at three educational institutions in the midwest region of the United States. A mixed method design would allow a future researcher the ability to capture participant qualities through interviews or open-ended questions. Motivational themes gleaned from the student interviews would provide future researchers a more detailed perspective about an individual student's motivation. The use of a qualitative component could provide meaningful results outside the constructs of the pre-determined response choices of a quantitative survey (Fraenkel et al., 2009). A qualitative study could reveal perceptions and motivations through interviews of students answering open-ended questions (Fowler, 2009).

Additionally, the researcher acknowledges the value of an expanded format for future studies. Expanding the survey to include questions about student's specific career intentions could provide a needed framework by which to evaluate findings. Finally, future researchers should consider including an aspect of their study to include questions about a participants history regarding changing majors.

As mentioned earlier, it is interesting to ponder whether students were influenced by the culture of the institution they attended to revere some motivational characteristics over others. Alternatively, students with differing motivations may be attracted to different institution types. Future researchers may consider collecting artifacts of institutional culture to provide insight into whether the observations made in the findings section can be attributed to the types of students who decide to attend the different institution types or if the culture of each institution has an effect on the stated motivations of its students. While it would be reasonable to assume that the culture of an institution will affect the students attending that institution, the degree to which this cultural influence effects science student motivations has not been well studied (Porter & Umbach, 2006).

Population and sample. The population of this study included students majoring in biology at several higher education institutions in the Midwest. The schools were selected based on their location, size, science degree offerings, and their status as a public, private, two-year, and four-year institution. Future studies conducted in different geographical areas may produce similar results, but also might show differences between geographical areas that could be related to socio-economic variables and the availability of science employment opportunities. Additionally, surveying students at multiple schools within each institution type would provide a more detailed and descriptive analysis of students representing those institutions. Increasing the number of participating institutions may lead to obtaining a larger sample. This would eliminate generalizations made of each institution type based on the surveying of a singular location.

This study did not capture participants representing minorities. An effort should be made in future studies to target higher education institutions with larger racial minority student enrollment. Increasing the number of study participants representing non-white races would allow meaningful insight into variations between these groups' motivations. Combining the previously mentioned qualitative focus, with better representation from minority groups could provide findings that better inform efforts increasing minority participation in STEM field.

Exploring ways to engage groups underrepresented in STEM education was a stated purpose of the report, A *strategy for American Innovation: Securing Our Economic Growth and Prosperity* by the NEC et al. in 2011. Another alteration to the sample could be the inclusion of other STEM majors and/or non-science majors. In this study the researcher chose to focus solely on biology majors to gain information about this group as a base line for future research. Future researchers may consider expanding the survey to students from other STEM majors. This could provide a comparison leading to specific motivations prominent in students from other STEM majors such as chemistry, physics, and geology.

While this study allowed the researcher to make findings relevant to biology student motivation, the researcher could not regard these findings as specific to science majors. Another comparison that could be made is that of rural students vs. urban students. Since this study surveyed students from three institutions in southwest Missouri, the findings are limited based on this designation. Expanding the study to include students attending higher education institutions in urban and metropolitan areas would allow student motivation comparisons to be made that are not possible with this regional study.

Instrumentation. While the published questionnaire used by the researcher utilized a five-point scale, future research may benefit from modifying the questionnaire response options to a four-point scale. Using a four-point system forces survey participants to a positive or negative general reaction to survey questions by eliminating the neutral response (Fowler, 2009). While it was informative to the researcher to know when participants had a neutral position for any particular survey item, forcing participants toward a positive or negative response would prevent the elimination neutral responses and thus provide more data available to the researcher for analysis.

Modification to the SMQII could be the addition of response items to identify a participant's status as freshman, sophomore, junior, or senior. The data gathered by such response items would allow the researcher to disaggregate the data into these status groups allowing the comparison of motivational factors between students of different statuses. Findings could illuminate, as mentioned previously, progressive changes in students' motivations and motivational sources as they advance closer to graduation and ultimately a career. A variation of this modification could be to administer pre-and post-surveys to the same group of advancing students. A survey conducted of students obtaining careers in a STEM field coupled with interviews of these participants could provide insight to the motivations prevalent in educational environments, and how those motivations translate in the workplace.

Summary

Improving the quantity and quality of American STEM workers in order to supply the demand for STEM jobs created by global competition and the desire to maintain and improve the United States' standing world-wide in this field has been the focus and overarching reason for STEM research (Atkinson & Mayo, 2010; Carnevale et al., 2011; Dickman et al., 2009; NEC et al., 2011). One mechanism for achieving these stated goals is to increase the number of students majoring in STEM educational fields (Dickman et al., 2009; Ewell et al., 2003). A review of the literature revealed little information as to the aspirations and motivations of students currently pursuing a college major in STEM areas. Some published studies focused on student major choice criteria in areas other than STEM (Malgwi et al., 2005; Tan & Laswad, 2009). Other studies focused on improving retention of students by identifying stumbling blocks for student degree completion (Ariza, Davis, Frye, & Harmsen, 2011; Bretell & Ault, 2010; Lloyd & Eckhardt, 2010).

In order to collect student motivation data regarding science student major choice criteria, an existing, published science student questionnaire, the SMQII, was used. The survey used in this study was administered electronically to students from a two-year public college, a four-year public university, and a four-year private university. Upon completion of the survey period, the results were analyzed leading to informative, new data about those science students' major choice motivations. As detailed earlier in this chapter, the findings revealed that science students did share high rankings of the motivations studied. Differences between the highest ranked motivations for students attending each of the different institution types were also observed. Disaggregated by sex and age of the participants reveal further differences upon which meaningful results and recommendations can be made. This new information about the motivational construct of the studied group of science majors can be applied to the previously stated problem of a lack of STEM majors in the American higher education system to provide workers required to fill the demand of a globally STEM-competitive United States (National Academy of Sciences et al., 2010).

By feeding the motivations of science students with curriculum based in real-world problems that meet the criteria defined by the workplace, today's higher education system can start a progress towards STEM pre-eminence that could provide a foundation supportive of innovative, meaningful, profession-ready graduates of the future (Dickman et al., 2009; NRC, 2007; Saxman, Gupta, & Steinberg, 2010).

Appendix A

Science Motivation Questionnaire II © 2011 by Shawn M. Glynn (Glynn et al., 2011) and motivational source questionnaire.

Part A. Science Motivation: In order to better understand what you think and how you feel about your college science courses, please respond to each of the following statements from the perspective of ‘‘When I am in a college science course. . .’’

[Response scale: * Never * Rarely * Sometimes * Usually * Always]

01. The science I learn is relevant to my life.
02. I like to do better than other students on science tests.
03. Learning science is interesting.
04. Getting a good science grade is important to me.
05. I put enough effort into learning science.
06. I use strategies to learn science well.
07. Learning science will help me get a good job.
08. It is important that I get an ‘‘A’’ in science.
09. I am confident I will do well on science tests.
10. Knowing science will give me a career advantage.
11. I spend a lot of time learning science.
12. Learning science makes my life more meaningful.
13. Understanding science will benefit me in my career.
14. I am confident I will do well on science labs and projects.
15. I believe I can master science knowledge and skills.
16. I prepare well for science tests and labs.
17. I am curious about discoveries in science.
18. I believe I can earn a grade of ‘‘A’’ in science.
19. I enjoy learning science.
20. I think about the grade I will get in science.
21. I am sure I can understand science.
22. I study hard to learn science.
23. My career will involve science.
24. Scoring high on science tests and labs matters to me.
25. I will use science problem-solving skills in my career.

Part B. Source of science major selection motivation:

To what degree (strongly disagree, disagree, neutral, agree, strongly agree) were the following factors used by you when deciding to major I science? I majored in science because...

1. Family member(s) majored in science.
2. Friends majored in science.
3. A teacher motivated me to pursue a major in science
4. I wanted to get a good job.
5. I wanted to solve meaningful problems.
6. I always made good grades in science

Appendix B

LINDENWOOD

LINDENWOOD UNIVERSITY ST. CHARLES, MISSOURI

DATE:	November 11, 2013
TO:	Stephen White
FROM:	Lindenwood University Institutional Review Board
STUDY TITLE:	[512463-1] Deciding on science: An analysis of higher education science student major choice criteria.
IRB REFERENCE #:	
SUBMISSION TYPE:	Revision
ACTION:	APPROVED
APPROVAL DATE:	November 11, 2013
EXPIRATION DATE:	November 11, 2014
REVIEW TYPE:	Expedited Review

Thank you for your submission of Revision materials for this research project. Lindenwood University Institutional Review Board has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to the IRB.

This project has been determined to be a Minimal Risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the completion/amendment form for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of November 11, 2014.

Please note that all research records must be retained for a minimum of three years.

If you have any questions, please contact Tameka Tammy Moore at (618) 616-7027 or tmoore@lindenwood.edu. Please include your study title and reference number in all correspondence with this office.

If you have any questions, please send them to IRB@lindenwood.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Lindenwood University Institutional Review Board's records.

Appendix C

August 1, 2013

Dear_________________,

This letter is requesting permission to conduct research at your institution. The research is a part of my doctoral dissertation in higher education instructional leadership at Lindenwood University in St. Charles, Missouri. The title of my dissertation topic is: *Deciding on Science: An Analysis of Higher Education Science Student Major Choice Criteria.* The research will involve science students at your institution completing an online questionnaire exploring their motivations for pursuing an academic major in the sciences.

The purpose of this research is to gain an understanding of the decision-making processes students employ when deciding on a college major, specifically science.

Please sign the attached permission letter and return in the enclosed envelope to approve this request. Alternatively, the enclosed letter may be scanned and emailed to: swhite[redacted]

If you have any questions, or would like additional information please feel free to call me at [redacted]. Thank you for your consideration of this request.

Sincerely,

Stephen W. White
Doctoral Student

References

Adams, W., Perkins, K., Podolefsky, N., Dubson, M., Finkelstein, N., & Wieman, C. (2006). New instrument for measuring student beliefs about physics and learning physics: The Colorado Learning Attitudes about Science Survey. *Physical Review Special Topics - Physics Education Research*, *2*(1), 1-14. Retrieved from http://link.aps.org/doi/10.1103/PhysRevSTPER.2.010101

Ajzen, I. (1991). Attitudes, personality and behavior. *Organizational Behavior and Human Decision Processes*, (50), 179-211.

Ariza, C., Davis, J., Frye, M., & Harmsen, E. (2011). Getting science students to PASS-UIW: A successful collaboration between students, staff, and faculty. *Learning Assistance Review*, *16*(2), 55-70. Retrieved from http://eric.ed.gov/?id=EJ960455

Atkinson, R. D., & Mayo, M. (2010). *Refueling the U.S. innovation economy*. Washington, DC. Retrieved from http://www.itif.org/publications/refueling-us-innovation-economy-fresh-approaches-stem-education

Beede, D., Julian, T., & Langdon, D. (2011). *Women in STEM□: A gender gap to innovation*. Washington, DC.

Bluman, A. G. (2009). *Elementary statistics: A step by step approach* (7th ed.). New York: McGraw Hill, Inc.

Boone, H. N., & Boone, D. A. (2012). Analyzing likert data. *Journal of Extension*, *50*(2). Retrieved from http://www.joe.org/joe/2012april/tt2p.shtml[8/20/2012

Bretell, D. C., & Ault, J. (2010). *Arts and science major / career choice survey report*. Saskatoon, Canada. Retrieved from http://artsandscience.usask.ca/students/majorcareer/pdf/report.pdf

Bryce, T. G. K. (2010). Sardonic science? The resistance to more humanistic forms of science education. *Cultural Studies of Science Education*, *5*(3), 591-612. doi:10.1007/s11422-010-9266-6

Budny, D., Paul, C. A., & Newborg, B. B. (2010). Impact of peer mentoring on freshmen engineering students. *Journal of STEM Education*, *11*(5), 9-24.

Bybee, R. W., & McInerney, J. D. (1995). *Redesigning the science curriculum.* (p. 149). Colorado Springs, Colorado. Retrieved from http://www.eric.ed.gov/PDFS/ED433179.pdf

Campbell, T., Der, J. P., Wolf, P. G., Packenham, E., & Abd-hamid, N. H. (2012). Scientific inquiry in the genetics laboratory: Biologists and university science teacher educators collaborating to increase engagement in science processes. *Journal of College Science Teaching*, *43*(3).

Carnevale, A. P., & Smith, N. (2011). *The midwest challenge: Matching jobs with education in the post-recession economy*. Washington, DC. Retrieved from http://www9.georgetown.edu/grad/gppi/hpi/cew/pdfs/midwest-challenge.pdf

Carnevale, A. P., Smith, N., & Melton, M. (2011). *STEM* (p. 112). Washington, DC.

Carnevale, A. P., Smith, N., & Strohl, J. (2010). *Help wanted□: Projections of jobs and education requirements through 2018* (pp. 1-56). Washington, DC. Retrieved from Help Wanted:

Clement, M. C. (2008). Selection with behavior- based interviewing. *Principal*, (February), 44-47. Retrieved from www.naesp.org

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Thousand Oaks, CA: SAGE Publications, Inc.

Dickman, A., Schwabe, A., Schmidt, J., & Henken, R. (2009). *Preparing the future workforce: Science, technology, engineering and math (STEM) policy in K-12 education. Public Policy Forum*. Milwaukee. Retrieved from http://publicpolicyforum.org/research/preparing-future-workforce-science-technology-engineering-and-math-stem-policy-k12

Dietrich, J., & Salmela-Aro, K. (2013). Parental involvement and adolescents' career goal pursuit during the post-school transition. *Journal of Adolescence*, *36*(1), 121-8. doi:10.1016/j.adolescence.2012.10.009

Dowd, A. C. (2012). *Community colleges in the evolving STEM education landscape□: Summary of a summit* (pp. 107-133). Washington, DC: National Academies of Science.

Drew, D. E. (2011). *STEM the tide: Reforming science, technology, engineering, and math education in America*. Baltimore: The Johns Hopkins University Press.

Ewell, P. T., Jones, D. P., & Kelly, P. J. (2003). *Conceptualizing and researching the educational pipeline* (pp. 1-8). San Jose, CA. Retrieved from http://www.higheredinfo.org/analyses/Pipeline Article.pdf

Fink, A. (2013). *How to conduct surveys: A step-by-step guide* (5th ed.). Thousand Oaks, CA: SAGE Publications, Inc.

Foster, E. (2010). A new equation: How encore careers in math and science education equal more success for students. *Encore Jobs*, 1-13.

Fowler, F. J. (2009). *Survey research methods*. (L. Bickman & D. J. Rog, Eds.) (4th ed.). Thousand Oaks, CA: SAGE Publications, Inc.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. (2009). *How to design and evaluate research in education* (7th ed.). New York: McGraw Hill, Inc.

Gallant, D. (2010). *Science, technology, engineering, and mathematics (STEM) education* (pp. 1-7). Columbus, OH. Retrieved from https://www.mheonline.com/glencoemath/pdf/stem_education.pdf

Gasiewski, J., Eagan, M. K., Garcia, G., Hurtado, S., & Chang, M. J. (2012). From gatekeeping to engagement: A multicontextual, mixed method study of student academic engagement in introductory STEM courses. *Research in Higher Education*, *53*(2), 229–261. doi:10.1007/s11162-011-9247-y

Gentile, L., Caudill, L., Fetea, M., Hill, A., Hoke, K., Lawson, B., … Szajda, D. (2012). Challenging disciplinary boundaries in the first year: A new introductory integrated science course for STEM major. *Journal of College Science Teaching*, *41*(5), 44-51.

Gibson, B. A., & Bruno, B. C. (2012). The C-MORE scholars program: Motivations for an academic-year research experiences for undergraduates program. *Journal of College Science Teaching*, *41*(5).

Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science motivation questionnaire II: Validation with science majors and nonscience majors. *Journal of Research in Science Teaching*, *48*(10), 1159-1176. doi:10.1002/tea.20442

Gnage, M. F., & Drumm, K. E. (2010). Hiring for student success: A perspective from community college presidents. *New Directions for Community Colleges*, *152*(Winter), 71-80.

Goldrick-Rab, S. (2010). Challenges and opportunities for improving community college student success. *Review of Educational Research*, *80*(3), 437-469. doi:10.3102/0034654310370163

Green, D., & Ciez-Volz, K. (2010). Now hiring: The faculty of the future. *New Directions for Community 152*(Winter). Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/cc.430/abstract

Halversen, C., & Tran, L. U. (2010). Communicating ocean sciences to informal audiences: A scientist-educator partnership to prepare the next generation of scientists. *The New Educator*, *6*(3-4), 265–279. doi:10.1080/1547688X.2010.10399605

Hamilton, M. B. (2009). *Online survey response rates and times*. Retrieved from http://www.supersurvey.com

Higher Learning Commission. (2013). The criteria for accreditation. Retrieved from http://www.ncahlc.org/Information-for-Institutions/criteria-for-accreditation.html

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few□? Women in science, technology, engineering, and mathematics*. Washington, DC: AAUW.

Hong, B. S., & Shull, P. J. (2010). A retrospective study of the impact faculty dispositions have on undergraduate engineering students. *College Student Journal*, *44*(2), 266-278.

Hvistendahl, M. (2009). Asia rising: Countries funnel billions into universities. *The Chronicle of Higher Education*, 1-14.

Jenkins, L. L. (2011). Using citizen science beyond teaching science content: A strategy for making science relevant to students' lives. *Cultural Studies of Science Education*, *6*, 501-508.

Kalevitch, M., Maurer, C., Badger, P., Holdan, G., Iannelli, J., Sirinterlikci, A., … Bernauer, J. (2012). Building a community of scholars□: One university's story of students engaged in learning science , mathematics , and engineering through a NSF S-TEM grant. *Journal of STEM Education*, *13*(4), 34-42.

Kuenzi, J. J. (2008). Science, technology, engineering, and mathematics (STEM) education□: Background , federal policy, and legislative action. *Congressional Research Service Reports*, *Paper 35*. Retrieved from http://digitalcommons.unl.edu/crsdocs/35

Lavin, A. M., Carr, D. L., & Davies, T. L. (2009). The male professor 's attire and student perceptions of instructional quality. *Research in Higher Education*, *4*, 1-15.

Lips, D., & McNeill, J. B. (2009, April). A new approach to improving science, technology, engineering, and math education. *Backgrounder*. Washington, DC: The Heritage Foundation.

Lloyd, P. M., & Eckhardt, R. A. (2010). Strategies for improving retention of community college students in the sciences. *Science Educator*, *19*(1), 33-41.

Malgwi, C. A., Howe, M. A., & Burnaby, P. A. (2005). Influences on students ' choice of college major. *Journal of Education for Business*, (May/June).

McConnell, D., Steer, D., Owens, K., Knott, J. R., Van Horn, S., Borowski, W., … Heaney, P. J. (2006). Using concept tests to assess and improve student conceptual understanding in introductory geoscience courses. *Journal of Geoscience Education*, *54*(1), 61-68. Retrieved from http://geology.wlu.edu/greer/mcconnell-v54n1.v3.pdf

Metcalf, H. (2010). Stuck in the pipeline: A critical review of STEM workforce literature. *InterActions: UCLA Journal of Education and Information Studies*, *6*(2).

Milgram, B. D. (2011). How to recruit women and girls to the science, technology, engineering, and math (STEM) classroom. *Technololgy and Engineering Teacher*, (November), 4-9.

National Academy of Sciences, National Academy of Engineering, & Institute of Medicine. (2010). *Rising above the gathering storm, revisited: Rapidly approaching category 5*.

National Academy of Sciences, National Academy of Engineers, & Institute of Medicine. (2011). *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*. Washington, DC: The National Academies Press.

National Economic Council, Council of Economic Advisers, & Office of Science and Technology Policy. (2011). *A strategy for American innovation: Securing our economic growth and prosperity*. Washington, DC: The White House.

National Research Council. (2007). *Rising above the gathering storm: Energizing and empowering America for a brighter economic future*. Washington, DC: The National Academies Press. Retrieved from http://www.utsystem.edu/competitive/files/RAGS-fullreport.pdf

National Science Board. (2010). *Preparing the next generation of STEM innovators: Identifying and developing our nation's human capital*. Arlington, VA.

National Science Board. (2012). *Research and development, innovation, and the science and engineering workforce*. Arlington, VA.

Organisation for Economic Co-Operation and Development. (2010). *PISA 2009 results: What students know and can do: Student performance in reading, mathematics and science*. Paris, France. Retrieved from http://www.oecd.org/pisa/pisaproducts/48852548.pdf

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079. doi:10.1080/0950069032000032199

Page, M. C., Bailey, L. E., & Delinder, J. Van. (2009). The blue blazer club□: Masculine hegemony in science, technology, engineering, and math fields. *Forum on Public Policy*, (Summer), 1-23. Retrieved from http://forumonpublicpolicy.com/summer09/archivesummer09/page.pdf

Peoples, C. (2008). Sputnik and "skill thinking" revisited: Technological determinism in American responses to the Soviet missile threat. *Cold War History*, *8*(1), 55-75. doi:10.1080/14682740701791334

Pietrzak, D., Duncan, K., & Korcuska, J. S. (2008). Counseling students' decision making regarding teaching effectiveness: A conjoint analysis. *Counselor Education and Supervision*, *48*(2), 114-132.

Porter, S. R., & Umbach, P. D. (2006). College major choice: An analysis of person–environment fit. *Research in Higher Education*, *47*(4), 429-449. doi:10.1007/s11162-005-9002-3

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. Washington, DC.

Sanders, M. (2009). STEM, STEM education, STEMmania. *The Technology Teacher*, *68*(4), 20-26. Retrieved from http://esdstem.pbworks.com/f/TTT+STEM+Article_1.pdf

Saxman, L. J., Gupta, P., & Steinberg, R. N. (2010). Cluster: University-science center partnership for science teacher preparation. *The New Educator*, *6*(3-4), 280-296. doi:10.1080/1547688X.2010.10399606

Sharkness, J., Jr, M. K. E., Hurtado, S., Figueroa, T., & Chang, M. J. (2011). *Academic achievement among STEM aspirants*. Los Angeles, CA. Retrieved from http://www.heri.ucla.edu/publications-main.php

Solinas, G., Masia, M. D., Maida, G., & Muresu, E. (2012). What really affects student satisfaction? An assessment of quality through a university-wide student survey. *Creative Education*, *03*(01), 37-40. doi:10.4236/ce.2012.31006

Tan, L. M., & Laswad, F. (2009). Understanding students' choice of academic majors: A longitudinal analysis. *Accounting Education*, *18*(3), 233-253. doi:10.1080/09639280802009108

Tapping America's Potential. (2008). *Gaining momentum, losing ground*. Washington, DC. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Gaining+momentum,+losing+ground#0

The President's Council of Advisors on Science and Technolgy. (2011). K-12 science, technology, engineering, and math (STEM) education for America's future. *Techdirections*, *76*(4), 42-47.

The President's Council of Advisors on Science and Technology. (2012). *Report to the President: Engage to Excel; Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. Washington, DC. Retrieved from http://www.whitehouse.gov/ostp/pcast

Titley, R. W., & Titley, B. S. (1980). Initial choice of college major: Are only the "undecided" undecided? *Journal of College Student Personnel*, *21*(4), 293-98.

Tobias, S. (1990). *They're not dumb, they're different: Stalking the second tier*. *Change* (Vol. 22, pp. 11-30). Tucson, AZ: Research Corporation.

Toulmin, C., & Groome, M. (2007). Building a science, technology, engineering, and math agenda. *National Governors Association*. Retrieved from www.nga.org

Twombly, S. B. (2005). Values, policies, and practices affecting the hiring process for full-time arts and sciences faculty in community colleges. *The Journal of Higher Education*, *76, Number*(July/August), 423-447.

United States Bureau of Labor and Statistics. (2014). STEM 101: Intro to tomorrow's jobs. *Occupational Outlook Quarterly*, (Spring), 2-12.

United States Commission on Civil Rights. (2010). *Encouraging minority students to pursue science, technology, engineering and math careers*. Washington, DC. Retrieved from www.usccr.gov

United States Department of Labor. (2007). *The STEM workforce challenge*. Washington, DC. Retrieved from http://www.doleta.gov/youth_services/pdf/STEM_Report_4 07.pdf

United States Department of Education. (2007). *Report of the academic competitiveness council*. Washington, DC. Retrieved from http://cahsi.cs.utep.edu/Portals/0/Resources/Literature/Report_of_the_AcademicCo mpetitiveness_Council.pdf

Wadhwa, V., Saxenian, A., Rissing, B., & Gereffi, G. (2008). Skilled immigration and economic growth. *Applied Research in Economic Development*, *5*(1), 6-14. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/cbdv.200490137/abstract

Williams, P. J. (2011). STEM education: Proceed with caution. *Design and Technology Education*, *16*(1), 26-35.

Winters, M. A. (2009, January). Stemming the tide. *City Journal*. Retrieved from www.city-journal.org/2009/eon0116mw.html

Zeidenberg, M., Jenkins, D., & Scott, M. A. (2012). *Not just math and English□: Courses that pose obstacles to community college completion* (No. 52). Community College Research Center. New York. Retrieved from http://ccrc.tc.columbia.edu/publications/obstacle-courses-community-college-completion.html?UID=1155

Vita

Stephen Wilson White was born in St. Louis, Missouri on May 4, 1967, the son of Marilyn White and Tuell White. After completing his Bachelor of Science degree in biology from Missouri State University in 1989, he entered Georgia Southern University in Statesboro, Georgia, receiving the degree of Master of Science in biology in August of 1991. Stephen worked as a professional in the field of environmental protection in Puerto Rico and Atlanta, Georgia, until 2001 when he started teaching science at Ozarks Technical Community College in Springfield, Missouri. Stephen accepted the position of Dean of Science, Technology, Engineering, and Math at the Florissant Valley campus of Saint Louis Community College in 2013 where he maintains his interest in improving STEM education.