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Examining STEM Undergraduate Persistence and the Differential Relationships Across Sex, Race, and Ethnicity Through Two-Factor Theory

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EXAMINING STEM UNDERGRADUATE PERSISTENCE AND THE DIFFERENTIAL RELATIONSHIPS ACROSS SEX, RACE, AND ETHNICITY THROUGH TWO-FACTOR THEORY

by

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Abstract

This study investigated the persistence of undergraduate students in science, technology, engineering, and mathematics (STEM) majors through two-factor theory. Proxies for STEM persistence factors were used as hygiene and motivator factors, which were categories of two-factor theory originally conceptualized to understand workplace determinants that extrinsically and intrinsically motivate employees. A two-block entry model was used to test multinomial regression analysis with outcomes for persisting in STEM, degree incompletion, and changing to a non-STEM major. This study also examined differential relationships of motivator factors across sex, race, and ethnicity due to underrepresentation in STEM fields. Data for this study were extracted from the Educational Longitudinal Study of 2002 (ELS:2002), a nationally represented survey conducted by the National Center for Education Statistics (NCES).

Among hygiene factors, the findings demonstrated that students with at least one parent with a bachelor's degree, attending a highly selective institution, and being able to pay for at least half of tuition and fees in the first term of study predicted whether STEM students remained in college. An additional hygiene factor of faculty interaction outside the classroom was also significantly associated with remaining in a STEM major rather than switching majors. This study also found that significance of undergraduate research, first-year GPA, and total GPA predicted STEM persistence as motivator factors. An additional motivator factor, receiving mentorship, was also associated with staying in a STEM major. A test of interaction terms also demonstrated that the effect of motivator factors does not vary by sex or race/ethnicity. Recommendations are discussed in support of the consideration of fostering intrinsic and extrinsic motivation in STEM persistence policy and interventions, as well as recommendations for future research.

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Chapter 1: Introduction

As early as World War II, the United States has benefited from the research advances in science and technology to maintain its global prowess and generate economic growth, according to a report by the National Academies of Sciences, Engineering, and Medicine [NASEM] (NASEM, 2007). However, since the turn of the 21st century, government and industry leaders have expressed concern over the shortage of a qualified workforce in science, technology, engineering, and mathematics (STEM). These leaders emphasize the need for high-quality, knowledge-intensive jobs in the United States and enterprises that will produce a steady stream of scientific and technological innovations (NASEM, 2007; PCAST, 2012).

Examining which fields had the highest deficits in STEM employees, Xue and Larson (2015) found that a heterogeneous mix of sectors in both government and private industries are most in need, experiencing shortfalls in employment in several types of engineering fields, computer science, cyber intelligence, and physics-related technical fields. Moreover, the 2016 U.S. News/Raytheon STEM Index, a measure that tracks key indicators of educational and economic changes in STEM activity, showed that science and technology sectors added 230,246 jobs between 2014 and 2015. However, the index revealed that there were only 30,835 additional STEM graduates in the same period, illustrating that the deficit continues to be problematic from a workforce perspective (U.S. News and World Report, 2016).

Likewise, the President's Council of Advisors on Science and Technology (PCAST, 2012) reported a need to increase the cultivation of a STEM-literate workforce, referred to as the STEM pipeline, to meet the demands of a technology-driven society. Citing an analysis by the Center on Education and the Workforce at Georgetown University by Carnevale, Smith, & Strohl (2010), PCAST (2012) projected that STEM occupations would increase from 5% of U.S.

jobs to 5.3%, representing a need for one million more STEM workers by 2018. In addition, the report stated that fewer than 40% of students who enter college with the intent to major in STEM complete a STEM degree, representing a potential crisis due to a shortage of qualified employees (PCAST, 2012). Focusing on bachelor's degree students, a report from the National Center for Education Statistics (NCES) found that 48% of students dropped a STEM major by either leaving college or switching to a non-STEM degree (Chen, 2013). In comparison, students in the humanities (56%), business (50%), education (62%), and health sciences (57%) fared worse, with higher institutional and major attrition rates (Chen, 2013). Despite attrition rates of other academic fields, the demand for more STEM graduates underscores the importance of STEM-related majors to the nation's welfare.

The National Academies of Engineering, Science, and Medicine (2007) emphasized several reasons to focus on science and technology, including ensuring economic well-being, the creation of new industries, promoting public health, improving the standard of living, and protecting the environment. Moreover, the report highlighted four major policy recommendations: (a) increase the talent pool of K-12 math and science educators through financial scholarships and strengthening the educational skills of current teachers; (b) invest more federal funds in research advancement; (c) increase the number of U.S. bachelor's and graduate degree recipients in STEM and create an environment to keep international STEM degree recipients in the United States; and (d) incentivize innovation through tax credits, a modernized patent process, and universalizing broadband internet access to increase information sharing (NASEM, 2007).

A decade after the National Academies of Sciences, Engineering, and Medicine report was published, STEM continues to be a focus of government interest and concern. This concern was echoed recently in the passing of two federal statutes: The American Innovation and Competitiveness Act (S. 3084, 2016) and Inspiring the Next Space Pioneers, Innovators, Researchers, and Explorers (INSPIRE) Women Act (H.R. 321, 2017). These laws were passed to increase and reward more technological innovation and research, increase the number of underrepresented minorities in STEM, and encourage more women to pursue STEM education and aerospace careers. These kinds of policy initiatives intended to increase the STEM workforce were significant enough to cross political lines and White House administrations. The Obama administration dedicated hundreds of millions of dollars to states to strengthen STEM education and increase access to both women and minorities, and the Trump administration has committed $200 million per year to technology education grants that encourage women and minorities to pursue coding and computer-based careers (Kullgren & Emma, 2017).

While there is a necessity for more STEM graduates overall, PCAST (2012) also emphasized the need for retaining more women and underrepresented minorities (URMs) to resolve the STEM workforce shortage; women and students of color represent 70% of all college students, yet they only represent 45% of STEM degree recipients. Additionally, Van Noy and Zeidenberg (2014) reported that black, Hispanic, and Asian undergraduate students major in STEM degrees at 9% for each race/ethnicity category, while 67% of white students study STEM (as cited in NASEM, 2016, Table 3). Furthermore, a look at sex shows that only 37% of STEM undergraduates are women (NASEM, 2016).

As reported by the NCES, 20% of STEM entrants dropped out of their institutions, and another 28% left a STEM major for a non-STEM major (Chen, 2013). Women were more inclined to stay in college but changed to a non-STEM major than men (32% vs. 26%), while 24% of men dropped out vs. 14% of women (Chen, 2013). The study also revealed some racial/ethnic disparity in STEM; 29% of black students and 23% of Hispanic students dropped out of college vs. 20% of white students. In addition, 36% of black students and 26% of Hispanic students changed their major to a non-STEM degree versus 28% of white students. On the other hand, only 10% of Asian students left STEM degrees by dropping out, and 23% of Asians switched to a non-STEM major (Chen, 2013). These statistics demonstrate a dire need to support the persistence of women and URMs as part of the solution to an increased STEM workforce.

Research Perspective

Given the deficiency of qualified STEM workers, researchers have attempted to study the attrition and persistence of STEM students in higher education. Some literature points to the culture of STEM academic environments as a barrier to student persistence, referring to cultural incongruence between students and the behaviors, values, and norms associated with STEM (NASEM, 2016). This culture is exemplified in the perception that science work is the domain of white males and therefore STEM work is not well suited to URMs and women (NASEM, 2016). Thus STEM culture may be especially troublesome for women and URMs who struggle with its norms, finding the STEM climate to be unwelcoming and challenging to navigate (Carlone & Johnson, 2007; NASEM, 2016). The issue with STEM academic environments is evident in previous research, which points to insufficient numbers of mentors and role models in STEM for women and minorities, a disinclination for the competitive environments prevalent in STEM academic experiences, and the perception of discrimination in STEM fields (Blickenstaff, 2005; Carrell, Page, & West, 2010; Chang, Eagan, Lin, & Hurtado, 2011; Chen, 2013; Daempfle, 2003; Eagan, Herrera, Garibay, Hurtado, & Chang, 2011; Espinosa, 2011; Fouad et al., 2010; Ost, 2010; Price, 2010; Seymour, 2001; Thompson et al., 2007).

Previous theories and conceptual models that explain STEM student persistence are rooted in qualitative persistence theory. These models intentionally explore factors of persistence that focus on the individual's perseverance rather than baseline factors that merely prevent departure (Carlone & Johnson, 2007; Graham et al., 2013; Lane, 2016). Scholars who study persistence and retention have echoed this sentiment in their research. For example, Rodriguez (1997) states that previous research focused on institutional and social factors that hinder student progress, arguing that researchers must redirect their attention toward understanding how underrepresented students succeed despite challenges associated with demographics. Likewise, Tinto (2006) stated, "Leaving is not the mirror image of staying. Knowing why students leave does not tell us, at least not directly, why students persist" (p. 6). There is an underlying implication that some factors may have a more significant impact on student persistence than others; from this viewpoint, STEM persistence studies seem to indicate that institutional efforts to prevent departure result in the minimum level of satisfaction required to retain the student but miss the opportunity to motivate students beyond basic needs (Graham, 2013; Lane, 2016). Therefore, there may be factors that can positively impact students' self-efficacy, motivating the student beyond par into higher-achieving levels.

There is support for this motivational, persistence-based phenomenon in Kuh's (2008) research on the compensatory effect of high-impact educational activities that encourage persistence in students who have characteristics statistically correlated with lower retention. Kuh (2008) found a compensatory persistence effect on all students who participate in active-learning practices, such as internships, undergraduate research, writing-intensive courses, and senior capstone projects. Moreover, URMs show higher gains than white students and students from higher-income families when paired with high-impact educational practices (Kuh, 2008). If this phenomenon applies to students in STEM environments specifically, then postsecondary institutions need to address two categories of STEM persistence, as some factors may support only baseline persistence, thereby preventing STEM departure, while other factors may boost persistence to more substantial levels.

While scholarly work on persistence, retention, and departure is vast, having increased since the 1970s, research on STEM persistence is a comparatively recent area of study. Quantitative studies on STEM persistence have found many variables to be significantly correlated with STEM persistence or departure by changing to a non-STEM major or leaving an institution. Significant factors negatively associated with persistence broadly include identities as URMs and women and coming from low-SES families, low secondary and postsecondary GPAs, unsuccessful academic integration and minimal faculty interactions, low participation in academic and STEM-career activities, decreased motivation and confidence in STEM, limited financial assistance, and unwelcoming educational environments (Chang, Sharkness, Newman, & Hurtado, 2014; Chen, 2013; Crisp, Nora, & Taggart, 2009; Whalen & Shelly, 2010; Xu, 2015). Additionally, researchers are beginning to examine the psychological components of STEM student persistence that can play a significant role in student success. Many of these studies have been rooted in qualitative studies that explore themes such as students' motivation, perceived drawbacks to completion, comfort level with STEM activities, and confidence in their ability to succeed in STEM courses, as well as conditions that affect their attitudes toward STEM persistence (Carlone & Johnson, 2007; Graham et al., 2013; Lane, 2016; NASEM, 2016; Perez, Cromley, & Kaplan, 2014).

Purpose & Research Questions

A review of past literature reveals that the motivational aspects of STEM persistence require further investigation. Given the perception of academic rigor, the demotivating educational environment, and poor persistence levels in the STEM student population, especially women and URMs, there need to be studies that combine and measure both baseline, extrinsic persistence variables from previous research and variables that can positively impact the intrinsic motivation of STEM students through the academic rigors of their disciplines.

Looking to the field of organizational psychology, a model of STEM student persistence that accounts for variables that are both extrinsic and intrinsic might be a modified framework of Herzberg's (1959, 1968, 2003) two-factor theory. Well-known in workplace and human resource theory, Herzberg's theory attempts to explain workforce persistence through extrinsic and intrinsic motivation factors. Two-factor theory explains workforce departure as the result of hygiene factors, external and environmental factors associated with employee dissatisfaction. Hygiene factors are categorized as salary, interpersonal relationships, administrative policies, working conditions, and the effect of work on personal life (Herzberg et al., 1959). On the other hand, employee persistence is hypothesized to be a result of motivator factors, which intrinsically motivate individuals. Motivator factors are identified as categories of employee satisfaction, specifically achievement, recognition, responsibility, advancement, satisfaction, and the work itself (Herzberg et al., 1959). Accordingly, a theory of STEM student persistence could be modeled on two-factor theory, with postsecondary educational variables for hygiene and motivator factors replacing workplace-related determinants.

Therefore, the purpose of this study is to understand which factors significantly predict the persistence of U.S. undergraduate students who pursue STEM majors by testing the utility of the two-factor theoretical framework. In addition, I seek to understand how two-factor theory may explain differences by sex and race/ethnicity. Given the focus on two-factor theory to understand the impact of STEM student persistence variables, this study will examine the following questions:

1. What is the persistence rate among STEM major students? Are there any sex and racial differences?
2. How do hygiene factors predict STEM student persistence?
3. How do motivator factors improve our understanding of STEM student persistence beyond the model with hygiene factors?
4. Do the relationships between hygiene and motivator factors and STEM student persistence vary significantly across sex and race/ethnicity?

Research Design

This research used a data set from a federal study known as the Educational Longitudinal Study (ELS). The ELS followed and examined students from early high school in 2002 through their post-educational experience in 2012. Using the ELS dataset, this study included a subset of students who started in STEM majors at the undergraduate level and predicted their persistence based on variables determined from the review of existing research literature to be equivalents for workplace motivator and hygiene factors under two-factor theory. Furthermore, using this dataset had the advantage of having a nationally representative distribution of students beginning in the 10th grade, as well as being able to account for persisting in STEM across any postsecondary institutions attended by staying in both a STEM major and completing a STEM degree. Using a hierarchical logistical regression model, this study tested the effect of hygiene factors on STEM persistence and then tested a second model incorporating motivator factors.

The significance of additional factors may be an indication that newly added variables are motivator factors, providing intrinsic motivation to students to persist over baseline hygiene factors. This study then followed up with a test of interaction terms on significant motivator factors to see how their impact is moderated by specific sex and race/ethnicity.

By reframing known persistence variables as hygiene and motivator factors, two-factor theory may be a useful framework to understand the persistence of students in STEM majors and thereby provide more guidance in policy-making and interventions to help students persist. The programs and policies intended to support STEM students can be tailored by educational institutions and government agencies to optimize students' persistence by addressing both hygiene and motivator factors for specific STEM student populations, especially women and URMs. Given the need for more STEM graduates, this study could potentially help postsecondary institutions address student STEM persistence using a two-pronged approach—interventions enacting baseline persistence and serving as a safety net to prevent students from leaving their STEM major, as well as implementing educational approaches that intrinsically motivate students through their program at more significant persistence levels.

Organization of Study

Reasonable proxies were determined to reinterpret and convert workplace factors into STEM persistence variables to examine how two-factor theory might apply to the STEM college student experience. To decide which variables to test, this study first reviews the previous literature on related persistence and retention theories that may relate to parallel workplace factors of two-factor theory in Chapter 2. Furthermore, Chapter 2 reviews previous research on college and STEM undergraduate persistence as related to the various categories of hygiene and motivator factors. In Chapter 3, I discuss the research method, describing both the dataset and the regression process of understanding which factors impact the dependent variable of persisting in STEM. Chapter 4 provides the results of the research, and finally, in Chapter 5, I discuss policy implications and their significance to educational policy and intervention.

Chapter 2: Literature Review

For the last 40 years, literature on college student persistence has focused on demographic, academic, and social characteristics of students, as well as the environments and interactions that students experience that may impact their educational success. Moreover, researchers since the turn of the 21st century have taken a particular interest in students who study STEM disciplines due to their significance for economic and national well-being, with an emphasis on those who are most vulnerable to attrition: women and URMs. In summarizing the past literature, this study reviews classic and modern theories related to the persistence, retention, and attrition of college students, with an emphasis on STEM students specifically. Additionally, I review the main categories of the previous research on persistence related to this study.

Definition of Terms

For the purpose of clarity, this study makes a distinction among the terms *persistence*, *retention*, and *departure*/*attrition*/*dropout*. I discuss persistence as an individual phenomenon whereby a student continues to the educational end goal, which can be regardless of degree attainment at a particular institution (Reason, 2009). I differentiate persistence from the notion of retention, an institutional phenomenon whereby colleges and universities retain their students. Furthermore, some studies describe the phenomenon of students discontinuing their education or leaving STEM as departure, dropout, or attrition. I include these studies where negative significance to STEM persistence is associated with a predictor.

Furthermore, this study reviews and examines previous literature from a persistence lens out of consistency with past research; several STEM persistence studies have taken this philosophical approach in order to understand how students persist despite experiencing challenges to educational success (Carlone & Johnson, 2007; Chang et al., 2014; Graham et al., 2013; Lane, 2016). Moreover, this study builds upon past research on STEM persistence by using a data source that tracks persistence to student degree completion regardless of how many educational institutions the student attended.

The persistence outcome for this study also includes whether the student pursued and completed a STEM degree, which further clarifies what is meant by STEM student persistence. A student who completes a bachelor's degree in a STEM major would satisfy the definition of STEM student persistence. A student who begins in a STEM discipline but changes majors and completes a non-STEM degree would not, therefore, meet this definition. This STEM departure outcome will be referred to as earning a non-STEM degree. Likewise, students who stop attending their institution, thereby not completing a degree, would also not meet the definition of STEM persistence. The departure outcome for this result is referred to interchangeably as attrition, dropout, and a no-degree outcome.

Finally, it is essential to understand a formal definition of STEM that is relevant to this study. STEM refers to the study of academic programs in science, technology, engineering, and mathematics (NASEM, 2016). However, the inclusion of specific disciplines by the federal government may vary due to program stipulations and the interest of particular agencies. For instance, the National Science Foundation (NSF) includes the disciplines of psychology, political science, and economics (Gonzales and Kuenzi, 2012). Likewise, the Department of Homeland Security (DHS) broadened its scope of disciplines categorized as STEM to include pharmaceutical sciences, econometrics, and quantitative economics. This study uses a narrower set of STEM categories based on an NCES report on STEM persistence from 2013 (Chen, 2013). This definition is based on a grouping of disciplines connected to science and technology fields and originates from a set of degree and certifications listings called the Classification of

Instructional Programs (CIP). CIP uses a two-digit code to classify occupational fields. The fields chosen for this study are agriculture/natural resources, biological and biomedical sciences, computer/information sciences/support technology, engineering technologies/technicians, mathematics and statistics, and physical sciences.

Theories and Models

To examine how two-factor theory might apply to the STEM college student experience, reasonable proxies were determined to reinterpret workplace factors as STEM persistence factors. In this next section, I discuss previous theories and conceptual models that may coincide with two-factor theory, and in making parallels, provide direction and added credibility to the conceptual framework for this study. These theories were used in conjunction with past research to make critical arguments for using specific factors from previous college and STEM persistence literature that may apply to two-factor theory.

Industrial model of student attrition.

One of the first known attempts to understand student persistence by using workforce turnover theory was made by Bean (1980), who conceived of the theoretical framework for the industrial model of student attrition. Influenced by Price's (1977) research on turnover in work organizations, Bean (1983) used education-specific factors as surrogates for Price's work turnover model, looking at student satisfaction and intent to leave. Bean's model is composed of several categories that impact student attrition: routinization, participation, instrumental communication, integration, and distributive justice. In addition, Bean (1983) used three surrogate measures in place of pay: grades, practical value, and development. In this respect, the industrial model of attrition was innovative in that it attempted to address the complexity of factors in student persistence and examined multiple variables that institutions could focus on and readily create policies around, based on organizational behavior of students.

Bean’s model demonstrates how factors such as earning high grades, opportunities, and the practical value of an intended degree are not just predictors correlated with persistence and attrition, but also psychological motivators. The most recent studies on STEM student persistence assert the necessity of attitudinal factors for student resilience in their chosen major, which is discussed later in this review (Graham et al., 2013; Lane, 2016; Perez et al., 2014). Bean's industrial model also included an awareness of the interaction between the student and the institution, a concept that was explored further by his contemporary Tinto (1975, 1992). While Bean created his model before many now-recognized factors significant to persistence and retention became known, the industrial model of student attrition is one of a few models attempting to encapsulate the college persistence experience through a comprehensive set of predictive variables using workforce-related factors.

Student integration theory.

Tinto’s (1975, 1987) theory of student integration may be the most well-known theory explaining student persistence through academic and social engagement, taking on a paradigmatic status in persistence and retention studies (Braxton, Sullivan, & Johnson, 1997). Tinto was among the first to conceptualize student persistence through a social interactionist lens, which reflected the interaction between students and their environment (Tinto, 1992). Tinto’s (1975) first model of student dropout, later renamed student integration (Tinto, 1987), was built on the earlier work of Spady (1970), based on Durkheim’s theory of suicide (1961), and eventually updated to include anthropologist van Gennep’s (1960) theory on rites of passage. Patterning his concept of the student experience on van Gennep’s theory, Tinto (1987) argued that students must go through three similar stages to be successful in college: separation, transition, and incorporation.

Tinto (1975) emphasized the social and academic dimensions of college; the success of integration is dependent on one's success in adopting explicit norms and values of the institution, such as participating in class and earning passing grades. Individual characteristics (high school experience, family background) contribute to a commitment to the institution and graduation, but ultimately meanings that the student ascribes to institutional social and academic interactions determine departure decision (Tinto, 1975). Moreover, Tinto (1993) addressed the formal and informal dimensions of integration in academic and social environments. Formal academic integration manifests through academic achievement; informal academic integration involves interaction with peers and faculty in academic-related activities. On the other hand, formal social integration relates to participation in extracurricular activities, while informal social integration requires social interaction with peers. Tinto’s theory has influenced and continues to influence persistence, retention, and attrition research. More on the significance of social and academic factors in studies are discussed in the research section of this chapter.

Theory of vocational choice.

Many students decide to leave STEM by changing to a non-STEM major (Borrego, Padilla, Zhang, Ohland, & Anderson, 2005; Brainard & Carlin, 1998; Chen, 2013; Espinosa, 2011; Ost, 2010; Rask, 2010). One of the first influential theories on this topic originates with a study by Holland and Nichols (1964). Holland created the theory of vocational choice (1959), whereby he asserted that there are six major types of personalities related to career choices and one's best vocational fit is determined by sharing similar personality types with the people who are already associated with the corresponding careers. Holland (1959) posited that the major types of vocational categories are realistic, investigative, artistic, social, enterprising, and conventional.

Relevant to the formation of this theory, Holland and Nichols (1964) studied a sample of National Merit Finalists in a high school composed of 832 boys and 181 girls, examining interest, personality, originality, and aptitude measures during high school, entry to college, and after their first year of college. The researchers found that remaining in a particular major was associated with having attitudes aligned closely with students who were typical of their chosen field, while switching majors was associated with having personality attributes that were dissimilar to others typically found in that major (Holland & Nichols, 1964). Interestingly, Holland and Nichols (1964) noted that engineering students tended to switch majors more than peers in other science majors, but they could not pinpoint a conclusive reason for that result. Since this early work on vocational interests in the field of career psychology, present research on STEM attrition, persistence, and retention is also proving to be pioneering into research on changing majors.

Cultural and social capital.

With regard to the importance of culture in STEM college student persistence, Pierre Bourdieu (1986) conceived the notion of cultural capital, whereby families pass down symbolic privilege to each generation. According to Bourdieu (1986), this phenomenon provides an advantage over others through three different forms: the embodied state, which encompasses values and cultural dispositions; cultural goods, which are inherited objects of value; and the institutionalized state, which originates from recognized qualifications, such as a college degree. Furthermore, Bourdieu (1986) states that social capital, the advantage gained from membership in a group and one's social connections, perpetuates and supports cultural capital.

As it relates to persistence, students with abundant and relevant cultural and social capital have better access to societal advantages and privileges than students with low cultural and social capital. Having access to cultural and social capital provides a would-be college student with the knowledge and expectations gained from family upbringing, as well as the support and influence of a family's social network (Perna, 2000). However, minorities and students from lower socioeconomic classes may not experience the same access to cultural and social capital and therefore are disadvantaged in their educational pursuits (Perna, 2000; Rosenbaum & Naffziger, 2011; Tierney, 2004). Consequently, Tierney (2004) states that institutions must provide cultural capital to minorities where barriers to persistence and integration exist, but he adds that students should not be required to reject their cultural identity to be successful. Therefore, social and cultural capital, are valuable assets in college persistence (Berger, 2000).

Accordingly, students may lack the cultural and social capital to successfully persist in their program, as there may be cultural barriers to persistence in academic settings (Chinn, 1999; NASEM, 2016). Argumentative discourse, for example, is a widely encouraged form of learning in many disciplines, and while it may vary by academic field, it is supported in STEM as the basis of the scientific inquiry (Hyland & Bondi, 2006; Erduran & Jiménez-Aleixandre, 2008). Obstacles may be embodied in cultural differences of educators who practice active and argumentative discourse in classroom settings if such practices are at odds with the cultural norms of students who do not reflect the majority (white, middle-high SES, and male) culture of STEM fields (NASEM, 2016). Supporting this concept, Aikenhead (2001) argues that few students outside the majority population have a worldview that is consistent with that of academic, and specifically, STEM learning practices. Since educators are often unaware of cultural differences, they may perceive these students as disengaged or may not notice these students at all. An additional challenge lies in the cultural view that inherent and natural ability is required to be successful in STEM fields (NASEM, 2016). This perception may be especially prevalent in gateway and introductory STEM courses where a competitive environment is fostered and students become selected out of these majors.

Moreover, concerning the lack of both cultural and social capital, underrepresented student populations are particularly vulnerable to transferring out of STEM majors or dropping out due to this non-supportive atmosphere (NASEM, 2016). The research on STEM student persistence suggest that there are too few role models and mentors for females and URMs and that there is a distaste among women for the competitive climate in STEM departments. Additionally, there exists perceived discrimination on the basis of sex and race/ethnicity, as well as feelings of isolation in STEM fields because not many peers pursue STEM degrees (Blickenstaff, 2005; Carrell et al., 2010; Chang et al., 2011; Chen, 2013; Chinn, 1999; Daempfle, 2003; Eagan et al., 2011; Espinosa, 2011; Fouad et al., 2010; Ost, 2010; Price, 2010; Seymour, 2001; Thompson et al., 2007). Cultural and environmental factors thus play a significant role in the discomfort of URMs and women with the STEM academic environment, thereby affecting their satisfaction with their STEM-related education.

Science identity.

STEM persistence literature emphasizes the importance of psychological and attitudinal factors in motivating students (Carlone & Johnson, 2007; Graham et al., 2013; Lane, 2016). Among the first to conceptualize the experience of STEM students in this way, Carlone and Johnson (2007) conceived and studied the notion of science identity through qualitative research with women of color. The science identity model initially examined the cross section of racial/ethnic and sex identity with the concepts of competence, recognition, and performance as a scientist (Carlone & Johnson, 2007). The theory explored the notion of a science person as first having *proficienc*y in the knowledge and understanding of science content. The second and most crucial component of the model involves *recognition* by relevant others who were already established in the science community, as well as self-recognition as a science person. The final feature of science identity is the ability to *perform* scientific practices, including the use of scientific language, the use of tools, and the enactment scientific methods (Carlone & Johnson, 2007).

Based on this theory, students who have fully developed science identities fall into two categories. The first is the research science identity, in which students see the importance of science for its own sake, showing interest in and understanding the natural world. The second is the altruistic science identity, in which the student redefines science identity with an interest in humanity and using science as a vehicle for altruism (Carlone & Johnson, 2007). A third category describes disrupted science identities, whereby students may experience being neglected or discriminated against, thereby inhibiting their full potential as a science person (Carlone & Johnson, 2007). The conceptual framework and qualitative study acknowledged that self-identify as a competent scientist and acceptance by others from the scientific community play a significant role in STEM student persistence.

Two-factor theory.

Looking to the field of organizational psychology, a model of STEM student persistence that separately accounts for factors leading to persistence and departure might be found using a modified framework of Herzberg's (1959, 1968, 2003) two-factor theory. Herzberg's theory explains workforce satisfaction through factors related to extrinsic and intrinsic motivation. The theory originates from research by Herzberg et al. (1959), who conducted a qualitative study using a critical-incident method; employees were asked to focus on different moments in work situations when they felt satisfied and dissatisfied. The researchers coded employee experiences into various themes, which became the basis for two separate categories of factors, *hygiene factors* and *motivator factors*. Moreover, the researchers argued that the opposite of dissatisfaction is not satisfaction, but a middle ground of no dissatisfaction, and likewise, the opposite of satisfaction is a neutral state of satisfaction, not dissatisfaction (Herzberg et al., 1959).

Consequently, two-factor theory explains workforce dissatisfaction as the result of inattention to maintaining hygiene factors, made up of external and environmental factors. The research found that hygiene factors fall into several categories: interpersonal relationships, administrative policies, working conditions, personal life, status, job security, and pay. Herzberg and his fellow researchers (1959) used the term *hygiene* to describe the maintenance-like function of these categories, comparing them to habits whereby people might clean and maintain themselves daily for proper health; addressing hygiene prevents negative results but does not necessarily create increasingly positive results beyond a baseline level. Therefore, experiences were categorized as hygiene factors due to their association with negative feelings rather than positive ones when these circumstances were not satisfactorily addressed.

In taking a closer examination of hygiene factors, the research by Herzberg et al. (1959) found that an essential factor affecting worker dissatisfaction was interpersonal relationships with supervisors and peers, as well as the nature of supervision provided in the workplace. For instance, regarding the concept of interpersonal relationships, respondents in the study indicated “critical incidents” where negative relationships with either a superior or coworkers were hindrances to productivity, and in some cases, led the employee to leave the organization

(Herzberg et al., 1959). Similarly, employees felt negative emotions when their supervision by a superior was not employee-centered; that is, the worker felt undifferentiated from the organizational majority rather than feeling uniquely valued as a contributing member of the company (Herzberg et al., 1959). Likewise, administrative policies and working conditions were often a source of dissatisfaction in the two-factor research, as both rules and procedures of working as well as physical environment can become obstacles to morale. Personal life was included as a category when working the job had an adverse effect on the employee's life outside of work. Moreover, status in the organization that is perceived as low and low job security were also significant sources of dissatisfaction. Lastly, pay or salary was considered a source of dissatisfaction when the worker was unable to live comfortably due to an inadequate wage. In the research, these factors are environment-related and therefore extrinsic in nature due to their hygiene-like quality; inattention to these aspects of work-life created an adverse effect on the attitudes of the employees.

On the other hand, employee satisfaction was theorized to be a result of motivator factors, intrinsically motivated determinants that have an encouraging influence on workers. Employees in the research were asked to recall moments of satisfaction in a work situation and describe their positive experiences, which were coded into specific categories. Thus, the categories of motivator factors from Herzberg's et al. (1959) research were *achievement, recognition, responsibility, growth, advancement,* and *the work itself*. These categories were found to increase and foster intrinsic motivation in employees, thereby increasing satisfaction and the potential for productivity in the worker.

Taking a closer look at motivator factors, a sense of achievement and recognition were among the most satisfying categories in the Herzberg research (1959), as these experiences cultivated a sense of worth and pride in employees. Similarly, enjoying the work itself and enacting a strong sense of responsibility provided workers with a sense of satisfaction and empowerment. Opportunities for growth and advancement in the organization in the form of promotions were also considered particular types of recognition, as they acknowledged the employee's capabilities. As explored in this early research, these categories differ from hygiene factors in that motivator factors can nurture and stimulate the worker's intrinsic motivation through the work experience beyond a minimal level of satisfaction.

There is potential to understand how students can succeed further in a STEM educational setting beyond extrinsic factors when applying the two-factor concept to college student persistence. Research on two-factor theory is prevalent in studies concerning work environments, yet two-factor theory has been rarely applied to understand college student persistence. One such study was conducted by Deshields, Kara, and Kaynak (2005) to predict satisfaction of business students at a state university in South Central Pennsylvania. The study showed some promising results, reporting the significance of some variables serving as motivator factors in student intent to persist in their academic program. The researchers found positive associations of faculty performance and satisfaction with classes on the intent to persist through a multifactor construct called the partial student college experience (Deshields, Kara, & Kaynak, 2005). Given the theory's potential utility in examining STEM college student persistence, this study will now turn to previous research to understand the educational factors that may coincide with two-factor theory's categorical variables and substantiate its use in a conceptual framework.

Previous Research

Previous studies have examined many possible factors in college student retention, persistence, and attrition phenomena from various perspectives, including academic, demographic, financial, cultural/environmental, and psychological. In recent years, researchers have examined these factors through the college STEM experience, observing similarities to and differences from the general college population. This section will summarize selected factors and related research that form and support the current understanding of college student persistence and where evident, STEM college student persistence.

Demographic factors.

Much of the previous research has focused on the significance of demographic and pre-college background factors of college student attrition and persistence. Student entry characteristics, such as sex and race/ethnicity, are standard variables that researchers have included, examined, and controlled for in past and current research, and moreover, are proven predictors of student persistence (Pascarella & Terenzini, 2005). In general, previous research shows that college women persist at higher rates than men; white and Asian students persist at higher rates than URMs, specifically blacks, Latinos, and Native Americans; and higher-SES students persist at higher rates than their lower-SES counterparts (Astin, 1997; Murtaugh, Burns, & Shuster, 1999; Peltier, Laden, & Matranga, 1999; Reason, 2001, 2009).

However, the literature also shows that the significance of demographic and background variables changes when interacting with other factors. For instance, in examining the interaction between race and SES, the persistence of race factors can be explained by SES, as many URMs come from lower-SES families and are therefore less likely to persist (Renn & Reason, 2013). When grouped with academic factors, demographic and socioeconomic predictors can be viewed through a lens showing that students from low-SES backgrounds may have attended K-12 schools and communities that are under-resourced and therefore fail to prepare them for college (Chen, Wu, Tasoff, & Weko, 2010).

Looking at STEM-specific persistence, there are similarities in persistence with the general college population; however, there are some differences when it comes to sex. Studies controlling for other factors in regression models have shown that URMs, first-generation college students, students from low-SES backgrounds, and women leave STEM at higher rates (Anderson & Kim, 2006; Chen, 2013; Hill, Corbett, & Rose, 2010; Shaw & Barbuti, 2010; Whalen & Shelley, 2010; Xu, 2015). For example, research has shown that students whose parents had less than a postsecondary education left STEM more frequently by dropping out than those with parents with bachelor's degrees or higher, and students in the lowest two quartiles of income level dropped out of college more frequently than those in the highest quartile of income level (Adamuti-Trache & Andres, 2008; Chen, 2013).

A national comparison of male and female students also shows some varying results; a 2009 study examining students beginning postsecondary education in 1995-1996 through 2001 reported that 32.9% of males began a STEM major versus 14.5% of females (Chen & Weko, 2009). However, STEM persistence demonstrated more parity between sexes, with 28.4% of women and 25.5% of men graduating with a bachelor's degree in a STEM field and 11.4% of women and 12.3% of men persisting at the time of the study (Chen & Weko, 2009). This study indicated that while fewer women choose STEM as a major, women who study in these disciplines do about as well as their male counterparts, though their combined persistence and degree completion numbers are still low. However, a separate study conducted by Crisp, Nora & Taggart (2009) comparing sex indicated different outcomes. Controlling for demographic factors, academic variables, and receipt of the Pell grant and using a sample of 1,925 students from a large doctoral-granting hispanic-serving institution who earned their undergraduate degree between 2006 and 2008, the study found that females were less likely to major in a STEM field in college and graduate with a STEM degree when compared with males (Crisp, Nora & Taggart, 2009).

Past research has also shown that race/ethnicity is significant to persistence in STEM. In a longitudinal study examining data from the Cooperative Institutional Research Program's (CIRP) 2004 Freshman Survey and 2008 College Senior Survey, Chang et al. (2014) found black and Latino students were less likely to persist than their white and Asian counterparts in a sample of 3,670 students from 217 institutions. However, pre-college characteristics moderated the effect of race; having higher SAT scores and a higher academic self-concept contributed to a stronger chance of persistence in a STEM field. Therefore, educational confidence may point to stronger academic preparation and opportunities for academic development as a significant factor for some URMs. Moreover, race was also moderated by academic programs (Chang et al., 2014), the most notable being the opportunity to participate in structured research programs. The study concluded that research activities provide URM students increased identification with their chosen STEM major, as well as collaborative support from other students (Chang et al., 2014).

A critical review of the previous research on demographics prompts the question of why these differences in persistence exist among various student populations. While demographic variables are correlated with STEM student persistence, their utility in interventions must be understood in context with other types of factors. Supporting this view, Pascarella and Terenzini (2005) stated that demographic factors allow researchers to understand the experience of specific student populations and how interventions may impact them. However, Renn and Reason (2013) argued there may be little that can be done to mitigate or influence demographic factors directly as predictors alone. The next sections discuss the interplay of cultural and environmental factors, financial determinants, and psychological factors to understand the other facets of STEM student persistence further.

Academic factors.

Previous research has noted the importance of focusing on the first year of study, as approximately 25% of freshman students will not return for their second year (Astin, 1975; Reason, Terenzini, & Domingo, 2006; Tinto, 1993). The National Student Clearinghouse (2018) reported that 73.4% of students persisted to their second year from fall 2016 to fall 2017, while 61.1% were retained at their original institution. Moreover, a few studies have demonstrated the significance of first-semester and first-year GPA on persistence (DeBerard, Spielmans, & Julka, 2004; McGrath & Braunstein, 1997; Rogulkin, 2011; Stinebrickner & Stinebrickner, 2003), as well as the effect of first-semester GPA on degree completion (Delaney, 2008; Gershenfeld, Hood, & Zhan, 2016; Jesse & Ellersieck, 2009; Yizar, 2010).

Regarding STEM-specific studies, prior research shows some inconsistent results. For instance, some studies have found that low grades in STEM courses and higher grades in non-STEM courses may lead students to leave STEM majors (Ost, 2010; Rask, 2010). The previously discussed NCES study focusing mainly on STEM course-taking and student performance outcomes revealed that 48% either left STEM majors or dropped out between 2003 and 2009, with 28% switching majors to a non-STEM major and the other 20% leaving college without a degree (Chen, 2013). The study also found that students in their first year were more likely to drop out with an overall average GPA of 2.3 and change to a non-STEM major with an average GPA of 2.6, compared with those maintaining an average GPA of 3.0, who persisted in STEM majors. The federal report also confirmed that switching to non-STEM fields was associated on average with having fewer STEM courses in the first year, taking remedial math classes in the freshman year, performing poorly in STEM courses as compared with non-STEM classes, and withdrawn and failed STEM credits (Chen, 2013).

However, beyond the first year, the probability of leaving STEM for a non-STEM major was greater in students with higher overall GPAs than low-performing students, thereby reversing the direction of finding's significance (Chen, 2013). This result has also been shown in other studies focusing on women in STEM; women tend to leave STEM majors for reasons other than grades, such as an unwelcoming academic environment, loss of interest in the major, and low self-confidence (Borrego et al., 2005; Brainard & Carlin, 1998; Espinosa, 2011). Moreover, the NCES study also found that the probability of dropping out was more significant when a student's overall college GPA was less than 2.5 as compared with high-performing students with a GPA of 3.5 or higher (Chen, 2013). Furthermore, leaving college was associated with poor performance in college, lower cumulative GPA, and higher levels of withdrawn/failed STEM courses (Chen, 2013).

From an academic lens, the studies described above generally indicate that early success in college and especially high achievement in STEM courses will likely lead to continued persistence for students in STEM fields if the academic environment is encouraging. When students do not have successful early experiences in college or experience an unsupportive academic climate, they may choose to either leave their intended STEM major or leave college altogether, as with the studies that examined the persistence of women and URMs. However, academic factors alone do not explain why students abandon their major or their college, actions which must be understood in context with other factors. Academic factors must be examined in association with demographic, financial, contextual, and psychological determinants to understand STEM student success fully.

Financial factors.

Early economic research on the effect of financial assistance on retention first examined the impact of financial aid on student attitudes (Chen, 2008), and later, broadly looked at how receiving financial aid affected retention (Astin, 1975; Stampen & Cabrera, 1986). Research on the impact of financial aid became more sophisticated with the distinction among the effects of financial aid by the type of financial assistance provided (Nora, Cabrera, Hagedorn, & Pascarella, 1996; Perna, 1998) and amount received (DesJardins, Ahlburg, & McCall, 2002; Paulsen & St. John, 2002). The literature on the impact of types of aid has proven to be inconsistent, revealing conflicting results. For instance, Peng and Fetters (1978) and Moline (1987) found that loans have no effect on persistence, yet Astin (1975), Chen (2008), and Voorhees (1985) found strong positive effects. Likewise, examinations of work-study show inconsistent results, as Pascarella and Terenzini (2005) found that this type of aid increases persistence, yet St. John and Starkey (1995) found that work-study decreases persistence for lower-middle income students.

Furthermore, research has examined the influence of specific types of financial aid on college persistence on a longitudinal scale, investigating how financial aid impacts persistence over a length of time and, more specifically, examining the effect of different types of aid, particularly need-based grant aid, on students of various demographic backgrounds (Chen, 2008). For instance, researchers found over a six-year observation period that the effect of financial aid type was particularly significant for URMs on the decision to persist with Pell grants, showing increasingly significant benefits by increments of $1,000 (Chen, 2008). The fact that state need-based grant aid has demonstrated similar effects on persistence provides substantial evidence that grant aid based on need improves persistence to degree completion for students from low-income families (Castleman & Long, 2013; Goldrick-Rab, Kelchen, Harris, & Benson, 2016). State grant aid has also been found to increase student persistence for STEM students over those who do not receiving grant funding (Anderson, Broton, Goldrick-Rab, & Kelchen, 2018).

Financial aid takes on added importance in retaining students as STEM degree-seekers may take longer to complete their degree (Chen, 2013; Fenske, Porter, & DuBrock, 2000; Whalen & Shelley, 2010). Time-to-degree may vary for STEM students due to diverse pathways into their chosen field, their chosen discipline, institution type, personal characteristics, and attendance at multiple institutions (NASEM, 2018). However, the research also shows some inconsistency in the effect of financial aid on STEM student persistence. For example, despite the positive impact of grant aid in the studies described earlier, the NCES report using national Beginning Postsecondary (BPS) data shows that Pell grant recipients dropped out at higher rates than non-Pell grant recipients, at 25% vs. 18%, respectively (Chen, 2013). However, in an institutional study comparing STEM students to non-STEM students by Whalen and Shelley (2010), all financial variables in their research proved to be significant predictors of persistence. For example, for every $1,000 increase in budgeted need, students were 5.8% less likely to persist. However, a $1,000 increase in loans, grant aid, and work-study, respectively, had significantly positive effects on persistence. Whether the impact is positive or negative, financial aid and financial need appear to be significant factors in determining persistence for STEM students. However, much like academic and demographic variables, the nature of significance is affected by the confluence of other factors.

Organizational and environmental factors.

In examining the factors of STEM persistence through an organizational and environmental lens, institution-specific factors have been found to be significant predictors and relevant variables in studies focusing on STEM student dissatisfaction with inadequate advising, career counseling, and overall institutional support (Chen, 2013). The importance of organizational factors can also be seen in differences among the types of institutions STEM students attend. For instance, those enrolled in four-year public institutions have a higher probability of leaving STEM by switching majors than students who began at four-year private nonprofit institutions, and STEM entrants at the least selective institutions had a higher probability of dropping out than those at highly selective institutions (Chang, Cerna, Han, & Sàenz, 2008; Chen, 2013).

These findings suggest that organizational elements within an institution may play a role in STEM persistence. In general, the lack of teaching competence of college faculty has been a disenchanting issue among students, as instructors are very knowledgeable but may lack training in effective communication (Jones, 2008). Unfortunately, STEM instruction by uninspired faculty is also a much-criticized and often-stated barrier to student persistence in STEM academic culture (PCAST, 2012). Traditional teaching methods use less-engaging lecture formats, whereas PCAST (2012) argues for more interactive methods in STEM teaching and learning. Seymour and Hewitt (1997) support this notion in a study examining 425 STEM undergraduates, revealing that practices of faculty make a “greater contribution” to STEM departure than characteristics of students or the appeal of non-STEM majors (p. 392). Dancy and Henderson (2010) also support learning strategies that actively engage students in STEM learning; rather than rote memorization and passive learning, these practices focus on student peer-to-peer interactions, conceptual understanding, critical thinking, and active learning techniques.

Another reason for STEM attrition is that STEM disciplines often foster a chilly environment for women and URMs. The literature often describes environments where these students are made to feel uncomfortable and demeaned by faculty and peers in STEM academic settings due to their sex and race (Allan & Madden, 2006; Chinn, 1999; Hall & Sandler, 1982; Wilson, 2000). However, research also shows that women and URMs can better succeed when faculty use pedagogy and teaching methods that embrace their gender and cultural identities, have faculty mentors whom they can identify with, and demonstrate the relevance of science material to them (Barad, 1995; Wilson, 2000). Therefore, attitudinal alignment with others can be considered one aspect of the cultural barriers to student educational satisfaction and persistence in STEM disciplines (NASEM, 2016). Moreover, students whose attitudinal attributes align with faculty and staff in their STEM program would be able to focus on their studies without concern, while those whose personality or background traits are not aligned may experience tension with the academic environment.

Academic advisement.

Another area of significance related to the institutional environment is the quality of academic advisement. The academic advisor may be a professional administrator or a designated faculty member who guides students through their program of study, relaying academic expectations, policies, and curriculum advisement. Previous research has shown that a close interpersonal and consistent relationship with an academic advisor will increase the likelihood of persistence, student success, and degree completion (Hale, Graham, & Johnson, 2009; Schnell, 1988; Vandermark, 2014; Winston & Sandor, 1984). In addition, academic advisement that is supportive and encouraging in nature is shown to be impactful for URMs and students from low-SES backgrounds toward persistence (Campbell & Nutt, 2008; Cuseo, 2003; Drake, 2011;

Habley & McClanahan, 2004; Hunter & White, 2004; Jordan, 2000; Light, 2001; Pascarella & Terenzini, 2005).

As STEM cultural environments are often barriers to persistence, past research has shown that academic advisors can play a vital role in helping students to succeed, but more often the experience of poor advisement is often a source of dissatisfaction and becomes an obstacle to persistence for STEM students (Corts et al., 2000; Keup & Stolzberg, 2004). While research on the effect of advisement on student persistence for all STEM majors is sparse, some studies examined the effect of advisement specifically on engineering majors. For example, Jain et al. (2009) found that poor advisement was a key indicator of attrition in engineering majors, and McCuen, Gulsah, Gifford, and Srikantaiah (2009) found that engineering students often receive inaccurate course information and inadequate time with advisors, and students rarely receive valuable information on financial assistance, career opportunities, and special projects from advisors.

These types of negative advising experiences may prove to be a deterrent to the persistence of STEM students who feel indistinguishable from other students and experience a lack of interest on the part of the academic advisor; STEM students are more inclined to persist when they have a supportive, personal relationship with an advisor who provides clear expectations and abundant resources to help them succeed (Hale, Graham, & Johnson, 2009; Schnell, 1988; Winston & Sandor, 1984). Furthermore, poor advisement may stem from faculty members who must provide this support to many students as a secondary responsibility to their primary and more institutionally valued duties of research, teaching, and service (Vowell & Farren, 2003).

Social and academic integration research.

A review of environmental factors must also consider research on social and academic integration theory, which has often been integrated into retention and persistence studies. According to previous research, factors related to social and academic integration may have a varied influence on STEM persistence. A significant study by Braxton and his fellow researchers (1997) previously tested Tinto's notion of social integration on general college students, finding only minor support for social integration on college student persistence and little support for academic integration. Braxton, Sullivan, and Johnson (1997) tested 13 propositions in Tinto's theory, finding significant results for five of the social integration propositions, primarily in residential institutions, and none for academic integration. Furthermore, only two of the propositions were found significant at commuter institutions, leaving doubt as to the ability of Tinto's theory to predict persistence.

These findings were echoed in institutional studies comparing STEM and non-STEM students, which concluded that social and academic integration factors might not play a statistically significant role in the persistence of students studying science and technology majors (Whalen & Shelley, 2010; Xu 2016). Instead, factors related to the perception of academic and institutional quality proved more significant to persistence, demonstrating the relevance of organizational factors over variables involving the social interactionist emphasis on student integration. There is also some indication that URMs and women can benefit from social and academic integration factors in the form of supportive institutional interventions (Espinosa, 2011). While institutional studies must be examined within the context of the local environment, these studies seem to support the notion that social and academic integration may have some minimal impact on STEM student persistence, but elements of the educational environment may prove more significantly supportive of or challenging to a student's persistence in a STEM major. This idea may demonstrate that positive interpersonal relationships with faculty and peers can create conducive conditions that allow students in STEM to focus on their studies, depending on how closely they work with faculty and peers, but negative interpersonal relationships may have a stronger impact and prove detrimental to STEM student persistence.

Undoubtedly, integration theory has had a significant impact on many studies examining the contextual factors of persistence and departure despite criticism and mixed results in research. Regardless, Tinto's theory continues to influence research models for retention studies (Braxton, Sullivan, & Johnson, 1997), including studies related to STEM student persistence, such as those found in the research of Espinosa (2009), Xu (2015), and Whalen and Shelley (2010).

Psychological factors.

Psychological factors, also referred to as attitudinal, psychosocial, and noncognitive factors, are another area of study requiring further examination. Current research examining psychological determinants of persistence has brought new light to the internal motivators that college students bring with them in conjunction with other factors. The significance of psychological factors on persistence was found in a meta-analysis of 109 studies by Robbins et al. (2004), who examined the relationship between psychosocial factors (PSFs) and study skills regressed upon two educational outcomes, performance, as evidenced by cumulative GPA, and persistence. Combining psychosocial theory models with other retention determinants, the researchers found moderately significant relationships between persistence and academic goals, academic self-efficacy, and academic-related skills (Robbins et al., 2004). The study also found incremental contributions of the PSF construct over and above factors of socioeconomic status, achievement on standardized tests, and high school GPA in predicting retention. The results of this research demonstrate that psychological factors affecting persistence may play a greater role in persistence than academic-based and demographic variables alone.

When it come to STEM attrition and persistence, a few studies examine psychological factors such as motivation, confidence, and belief in the ability to learn STEM subjects (Brainard & Carlin, 1998; Burtner, 2005; Huang, Taddese, & Walter, 2000). Russell and Atwater (2005) support the development of intrinsic motivation and the maintenance of perseverance in the success of black students through the STEM pipeline through family support and teacher encouragement. Similarly, the development of self-efficacy is encouraged in Latino students in a few studies through faculty mentors and family support (Anaya & Cole, 2001; Cole & Espinosa, 2008; Torres & Solberg, 2001). High academic self-concept and self-confidence is a significant predictor of STEM persistence, particularly for women and URMs (Brainard & Carlin, 1998; Chang et al., 2014). Qualitative research has offered much to the attitudinal persistence literature on women and URMs in STEM, which includes the science identity model (Carlone & Johnson, 2007). Lane (2016) takes this research further by testing specific interventions to help encourage URMs to persist through holistic support, community building, STEM identity catalysts, and proactive care.

Moreover, a few institutional studies have concluded that their results are connected to attitudinal factors. For example, Whalen and Shelley (2010) speculated that retention and attrition rates of students who switch between non-STEM and STEM majors might be attributed to perceptions of the difficulty of STEM courses and one's perceived ability to perform. Moreover, the study conducted by Xu (2016) that examined institutional STEM attrition explored student interest and motivation in academic activities, as well as the commitment to degree completion. Xu's research showed that motivation through active learning plays a significant role in persistence for STEM students, once again demonstrating that the interaction between psychological factors and environmental factors points to specific institutional activities that influence students to persist. The study also reiterates a common theme of motivation as a critical factor in STEM persistence research.

Motivation in STEM is also linked to whether students have explored their academic interests and their perceptions related to their program of study, thereby affecting persistence. A few known studies have connected pre-college experience in science with postsecondary success in STEM (Adumuti-Trache & Andres, 2008; Perez et al., 2014). Students who did not explore STEM, called foreclosed identities, were less likely to feel competent and experienced higher perceived effort, opportunity, and psychological costs (Perez et al., 2014). In contrast, the researchers found that students who report high exploration of STEM before committing to their career path were more likely to feel a high level of competence and perceive a greater value and sense of worthwhile investment in their chosen major (Perez et al., 2014). The significance of early exploration and confidence in STEM was also found in the dissertation work of Aryee (2017), who examined STEM persistence using ELS data. These findings suggest that early competence developed through science exploration can lead to higher perceptions of competence and value in the STEM major, leading to a stronger commitment to persist.

High-impact educational practices.

Taking exploration of science into account, there is evidence that engagement through science-related activities supports persistence in STEM students through deep learning and engagement. Previous literature has shown some potential for high-impact educational practices (HIPs) and the use of engaging activity-based learning to increase motivation, especially undergraduate research by URMs, to help them persist and succeed in their STEM-related studies (Dancy & Henderson, 2010; Espinosa, 2011; Kuh, 2008; Xu, 2016). These types of educational activities, as in the case of HIPs, may counteract attrition and encourage persistence, and show further promise by encouraging a compensatory effect on women and URMs who experience obstacles to educational success (Kuh, 2008).

According to Kuh (2008), these types of activities work by encouraging the student to invest substantial time and effort, fostering substantive relationships with faculty that fuel interaction and feedback, exposing the student to diversity and new perspectives, and synthesizing and testing student knowledge in meaningful settings outside the classroom. Additional research has connected the effectiveness of HIPs to the positive effect of student engagement and integration, verifying the significance of close interaction with and supportive feedback from faculty (Sweat, Jones, Han, & Wolfgram, 2013). However, Johnson and Stage (2018) found a weak relationship between specific HIPs and persistence, finding freshman seminars and learning communities had a slight negative correlation with graduation. The researchers also found a negative relationship between internships and graduating in four years and no relationship between internships and graduating in six years. Only undergraduate research was found to positively predict persistence at the least selective institutions, while no other significance was found for HIPs (Johnson & Stage, 2018). Moreover, little is known about the psychological and noncognitive reasons behind the effectiveness of HIPs. Researchers have speculated and hinted at the intrinsically motivating effects of HIPs, but this is an area requiring further research to understand STEM student persistence.

Assessment of literature.

Given the many theories and a vast number of studies about college student persistence, there exists a solid foundation of knowledge on which to examine STEM-specific persistence issues through several lenses. Previous literature, retention, departure, and persistence research is dominated by studies on demographic and academic factors. Decades of research have indicated that URMs and poor academic performance are correlated with lower persistence. The consistency of this research indicates the complexity of factors related to student success and persistence, and perhaps the challenge for educators to help these populations to succeed.

Academic factors related to student persistence are also well studied, demonstrating the significance of academic variables before and during college on the ability to persist. Of note, the NCES report showed a higher probability of high-GPA students leaving STEM over lower-GPA students (Chen, 2013). This peculiarity may point to both organizational and psychological obstacles to persistence that require further examination. Furthermore, the inclusion of financial factors in studies have become more common in the last decade, indicating some significance in the availability of financial aid on student persistence outcomes. However, in the case of STEM students, positive effects of financial aid may be outweighed by other factors, as evidenced in the NCES report demonstrating the strength and significance of other variables that are barriers to STEM persistence.

Moreover, previous studies examining social and academic integration, a widely accepted theory of college student retention, appear to diminish the utility of the theory, as there is only partial empirical significance in general retention studies and no significance in a few STEM persistence studies (Braxton et al., 1997). While some research shows the significance of social and academic integration through peer support for specific populations, such as women of color

(Espinosa, 2011), other studies show that this factor has no significance (Xu, 2016). Furthermore, there also appears to be some evidence of divergence from the non-STEM college population related to known factors that support retention through student engagement. Specifically, Whalen and Shelley's (2010) finding that learning communities have no significant effect on STEM student retention and Xu's conclusion that student social and academic engagement factors seem to be of lesser importance point to specific differences in the STEM population from the general student population. The mixed results of social integration theory demonstrate that persistence research is inconclusive in this area of study.

However, there does appear to be significance to environmental and cultural factors on STEM student persistence. Previous research has provided some insight into the environmental effect of cultural and organizational factors on persistence, as well as describing the experience of students studying STEM majors through a psychological lens. Studies examining cultural and environmental variables reveal there are challenges inherent in the academic environment due to the perception of STEM majors are more rigorous disciplines than other academic majors (Whalen & Shelley, 2010). Moreover, academic determinants and educational quality, both related to environmental factors of persistence, appear to play a significant role for STEM students (Xu, 2016). When faculty use engaging methods for student learning and STEM students engage in undergraduate research, there is a positive effect on persistence (Chang, 2014; Espinosa, 2011; Xu, 2016). On the other hand, when the teaching methods are only lecture-based and students perceive the academic environment as culturally unwelcoming, there is an adverse effect on STEM student persistence, especially for URMs and women (NASEM, 2016).

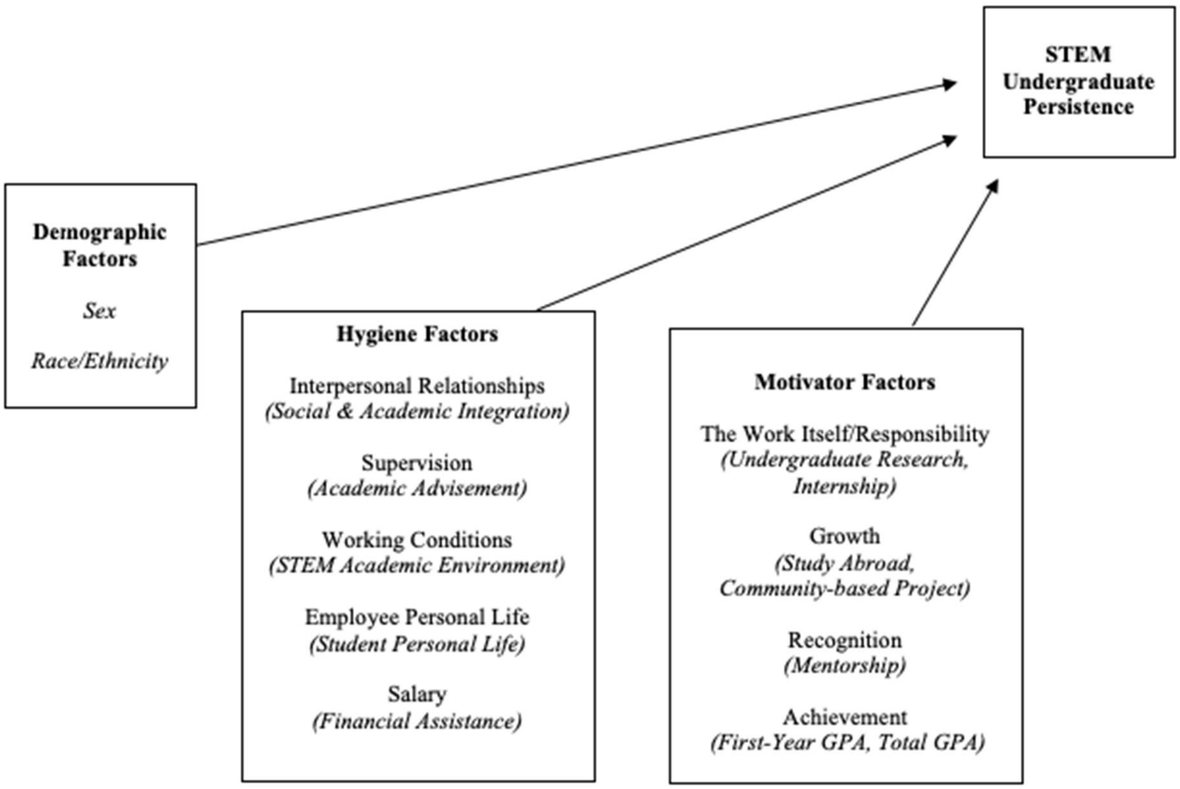
Moreover, there is a need to understand more about psychological factors and high-impact programs that may serve to increase a student's intrinsic motivation, thereby positively impacting persistence. The literature has shown the significance of HIPs and engaging activity-based learning formats as means of counteracting attrition and encouraging persistence by increasing intrinsic motivation, particularly in URMs. It is, therefore, a reasonable direction of study to explore how intrinsically motivating factors influence STEM persistence along with other well-studied determinants of persistence, such as demographics, achievement variables, financial factors, and social/academic integration.

To this end, quantitative research on STEM student persistence examining motivational factors is scarce. The studies that do exist seem to support qualitative research findings regarding the significance of psychological and environmental persistence factors for STEM students. Overall, the review of the literature suggests the need for more studies examining the environmental/cultural variables and factors related to the psychologically motivating factors of STEM student persistence. There is specifically a dearth of quantitative research explaining the attrition and persistence of STEM students from these perspectives, considering that both the challenges to and encouragement of STEM persistence seem to branch from environmental and attitudinal experiences.

Conceptual Framework: Two-Factor Theory

Herzberg's two-factor theory may serve as a useful conceptual framework to examine how motivational factors may predict STEM student persistence, but with the incorporation of postsecondary educational factors of departure and persistence rather than workplace-related factors. The theory has the advantage of testing predictors of persistence using a mix of extrinsically and intrinsically motivating factors. Therefore, the conceptual framework for this study calls for three sets of factors to be explored: demographic factors, hygiene factors, and motivator factors, as depicted in Figure 2.1. The original two-factor theory categories are displayed in plain text, while their corresponding proxies in STEM persistence variables are provided in italics. This next section will make arguments for the use of specific STEM persistence factors to be included and become proxies for the original study's workplace factors.

Figure 2.1 *Conceptual Framework*



Demographic factors.

The conceptual framework begins with the inclusion of student demographic factors for sex and race/ethnicity. Previous literature demonstrates that women and URMs often persist less than men and white students in STEM academic programs, though the departure outcome may look different, as in the case of the NCES study, which reported that women tend to switch to non-STEM majors while men tend to leave STEM programs by dropping out of the institution (Chen, 2013). However, past research shows that such effects can become moderated by the impact of predictors that support persistence. For example, a few studies have demonstrated the impact of participation in undergraduate research as a significant predictor of STEM persistence (Chang, 2014; Espinosa, 2011; Xu, 2016). The significance of undergraduate research demonstrates how institutions can have an impact on students regardless of any challenges that may be associated with their demographic background.

Hygiene factors.

Applying two-factor theory to the STEM college student experience, many known factors of student retention would be categorized as hygiene factors, as they are linked to extrinsic motivation. According to Herzberg et al. (1959), addressing these factors would create a neutral level of satisfaction, but not addressing hygiene factors would increase the likelihood of dissatisfaction and turnover. When applied to STEM undergraduate persistence, Herzberg's workforce categories for hygiene factors can convert to reasonable proxies for baseline persistence variables.

Based on previous research, the following STEM persistence factors can be organized under respective two-factor theory hygiene categories: interpersonal relationships, academic environment (working conditions), academic advisement (supervision), personal life, and financial assistance (salary). The next section will make some arguments for the conversion of two-factor theory categories into STEM student factors based on previous theories and studies.

The first hygiene factor, interpersonal relationships, has similarities to its closest proxy, academic and social integration. As discussed in the literature, Tinto's theory (1975, 1986) of student persistence and departure describes the impact of formal and informal relationships formed with faculty and peers through interactions, student involvement, and educational/ classroom activities on student retention. This phenomenon closely mirrors the experience of interpersonal relationships with supervisors and colleagues in the workplace. The finding of

Herzberg et al. (1959) that workplace relationships may often be the cause of dissatisfaction rather than satisfaction may support the notion that interpersonal relationships have less impact as a positive determinant of persistence than as a factor that may be negatively correlated to STEM persistence. Therefore, the category of interpersonal relationships can reasonably incorporate factors such as faculty interaction and extracurricular involvement.

The next hygiene factor is supervision; this category may best correspond with academic advisement as an education-related equivalent due to its overseeing nature. In the two-factor theory study, employees felt negative emotions when their supervision was not employee-centered and when they felt undifferentiated from the company masses rather than uniquely valued (Herzberg et al., 1959). Based on the literature, these feelings mirror the dissatisfaction of STEM students who may feel indistinguishable from other students and experience a lack of interest on the part of the academic advisor (Corts et al., 2000; Keup & Stolzberg, 2004). Given the similarity between worker supervision and academic advisement, this category can be represented by variables that directly address a STEM student's interaction with an academic advisor.

The third hygiene category, working conditions, corresponds to the academic environment and educational climate that STEM students may experience. While the original study by Herzberg and his fellow researchers describes this category in terms of the physical work environment of facilities, location, and equipment, there is little in the literature of STEM student persistence that speaks to these kinds of factors. However, much of the previous literature discusses the experience and impact of the STEM academic environment and institutional selectivity on persistence (Allan & Madden, 2006; Chang et al., 2008; Chen, 2018; Chinn, 1999; Hall & Sandler, 1982; NASEM, 2016; Wilson, 2000). The academic conditions that may support or hinder students, therefore, have less to do with physical conditions than the psychological space that is fostered by faculty, peers, and administrators. Hence, it is reasonable to represent this category with variables representing institutional selectivity, students' satisfaction with their education, or other factors that can speak to their contentment with the academic climate.

The category of personal life relates to the effect of a job on an employee's personal life outside of work. The impact on personal life was often discussed by the employees in Herzberg's (1959) research when the impact was negative, thereby making it a hygiene factor. Hence, factors related to the personal life of STEM students are included in the conceptual framework when these issues become related to persistence barriers.

As the final hygiene category, Herzberg et al. (1959) theorized that *salary* is a hygiene factor because it enabled employees to have the necessities to live adequately, thereby preventing dissatisfaction in the workplace but not necessarily increasing satisfaction. In the study, workers often complained when pay was perceived as unfair or insufficient in distribution. Moreover, pay was rarely described positively as a motivator unless it was perceived as recognition for their performance through a bonus or pay raise (Herzberg, 1959). Therefore, the conceptual construct for this study will use financial factors related to paying for school to meet the criteria for salary.

As financial factors, financial aid and the ability to pay for education can help STEM students to persist. However, the ability of financial factors to impact persistence can change or possibly reverse due to the potential interaction with other variables, as in the case of STEM students who receive Pell grants. (Chen, 2013). This finding from the NCES report points to the moderation and interaction of other variables with financial aid that can impact the ability to persist. Therefore, factors that include specific types of financial assistance are included in the conceptual framework to further test the ability of financial variables to impact STEM persistence.

Motivator factors.

The third set of persistence factors in the conceptual framework is the motivator factor category. Herzberg et al. (1959) found that respondents described specific experiences that would increase their satisfaction with work, which the researchers categorized as motivator factors. In these cases, the respondents were recalling critical incidents that were intrinsically motivating.

A review of previous research reveals that several persistence factors can be organized under two-factor motivator categories. These motivator factors for the conceptual construct are undergraduate research with a faculty member (the work itself, responsibility), internships and co-ops (the work itself, responsibility), study abroad (growth), service learning/community projects (growth), mentoring (recognition), and a high GPA (achievement). Each persistence variable may be associated with more than one motivator factor because they entail multiple dimensions of intrinsic motivation; however, the theoretical framework is presented here with a primary motivator factor category where possible. The next section will discuss these factors further, drawing from previous research to argue for their connection to two-factor motivator categories.

The original two-factor study showed that employees felt great satisfaction from doing work that they enjoyed and felt that they were making a positive and significant contribution. Likewise, those workers who were given more responsibility felt satisfaction in their work because their supervisors trusted them and believed they were capable (Herzberg et al., 1959). Similarities can be found in previous research on the impact of undergraduate research, which has been proven to be a highly effective practice for STEM persistence (Chang, 2014; Espinosa, 2011; Kuh, 2008; Xu, 2016). This type of activity directly engages STEM students in stimulating work related to their discipline of interest and provides them with increased responsibilities from faculty members who oversee the projects. Therefore, undergraduate research is included here under the motivator factor categories of both the work itself and responsibility. Along with research, the conceptual framework includes participation in internships and associated co-op/field experience. Both kinds of activities have been found to have positive effects on students as HIPs (Kuh, 2008).

Looking to the next category, Herzberg et al. (1959) explored the category of *growth*, which was the opportunity for employees to receive additional training and develop themselves. The researchers hypothesized that growth was a motivator factor because it served as a means for employees to foster interest in their work and increase their sense of worth. In the realm of STEM student persistence, growth may be observed in student attitudes regarding their academic abilities. Students who exhibit confidence and view their performance as opportunities to grow may effectively persist through their program (Brainard & Carlin, 1998; Burtner, 2005; Carlone & Johnson, 2007; Huang et al., 2000). Growth may also be observed in student participation in developmental types of activities. While these activities can include many kinds of HIPs, experiences of study abroad and service-learning/community projects are attached to this category specifically due to the emphasis in developing student perspectives through exposure to diversity and synthesizing their learning experiences through personal development (Kuh, 2008).

The next category to be included in the conceptual framework is recognition. This category was central among many workers who were satisfied with their jobs due to receiving recognition for their work as valued-employees (Herzberg et al., 1959). Interestingly, this category is shared with Carlone and Johnson's (2007) science identity theory as a necessary component of STEM persistence. Both research and altruistic science identities were fostered when faculty and other significant persons at and outside of the institution recognized students as competent scientists. Of importance to recognition, I included mentorship in the conceptual framework to represent this category. Mentorship by faculty members shows that they recognize the capabilities and the potential of a student to excel in the student's discipline (Carlone & Johnson, 2007; Kuh, 2008).

Moving on to GPA, the conceptual framework used this factor as a proxy for feelings of achievement. GPA is a representation of grades and credits earned, which has some parallels to receiving a salary for work in two-factor theory, a hygiene factor. However, when pay is represented in the form of a pay raise or bonus, it is viewed as recognition and achievement, a motivator factor in two-factor theory. Therefore, earning a high GPA may be viewed similarly by students as achievement in the STEM academic program although some research shows that this sense of achievement becomes moderated by unsupportive STEM environments (Borrego et al., 2005; Brainard and Carlin, 1998; Espinosa, 2011). For this reason, total GPA and first-year GPA are factors included in the conceptual framework, which tested their effect on STEM persistence and any interaction with other predictors. Previous research showed that the average GPA leading to STEM persistence is a 3.0 (Chen, 2013), so theoretically higher GPAs were hypothesized to reflect positively on the persistence outcome.

As an additional component of the conceptual framework, this study added motivator factors to the initial set of hygiene factors to examine the persistence outcome for STEM students. Hygiene factors would provide a baseline means of persistence for STEM students. Students may persist depending on the quality and amount of hygiene factors experienced, but those who encounter hygiene factors with dissatisfactory circumstances are theorized to have higher odds of STEM departure by dropping out or changing their major. Moreover, the addition of motivator factors was theorized to improve the model and increase the odds of STEM student persistence. Given that most of the variables chosen for motivator factor categories are also HIPs, these factors were theorized to show a compensatory effect that improves the persistence outcome over known barriers from the research (Kuh, 2008). I theorized that this would especially hold true for women and URMs, who may be more inclined to persist when they participate in these supportive activities.

Chapter Three: Research Design

As previous studies have shown, researchers have much to explore when considering the experience of students in the STEM disciplines, particularly for URMs and women pursuing degrees in these majors. This study builds on previous research by achieving three objectives: (a) examining how motivator factors may contribute beyond other known factors to student persistence through intrinsically motivating activities and practices within the college environment, (b) testing two-factor theory by researching student persistence in STEM fields through the use of existing nationally representative data, and (c) examining how the relationships between motivator factors and STEM persistence vary by race and sex. The process recategorized two-factor theory's notion of hygiene and motivator factors as known STEM persistence variables.

Through hierarchical multinomial logistic regression, this study tested the relative risk of variables predicting STEM student persistence outcomes with an initial block-entry using demographic and hygiene factor variables to the first model, and a second block-entry that included the addition of motivator factor variables to the second model. Relevant interaction terms were tested to examine how significant motivator factors may vary by sex and race/ethnicity. This study remedied the limited research of intrinsically motivating factors in STEM student persistence, examined whether variables categorized as motivator factors can impact persistence beyond hygiene factors when applied to the model, and additionally, investigated any differences in the way motivator factors may affect URMs and women.

Data Source

This research used a national dataset known as the Educational Longitudinal Study of 2002 (ELS:2002), conducted by NCES. Examining college access and persistence patterns, ELS:2002 followed and surveyed students over a decade, from their second year of high school in 2002 through their post-education experience in 2012. The NCES administered surveys at four time-intervals throughout the study: 2002, called the base-year survey (BY); 2004, called the first follow-up survey (F1); 2006, referred to as the second follow-up survey (F2); and 2012, the third and final follow-up survey (F3).

The base-year survey was executed with a nationally representative probability sample of 750 public, private, and Catholic schools in the 2001-2002 spring term; 15,400 students completed the questionnaire out of 17,600 eligible sophomores, an 87% response rate (Bozick & Lauff, 2007). The schools were selected first, with students then selected randomly within each school. Asian students were sampled more than black, Hispanic, and white students to provide sufficient racial/ethnic category comparisons. Institutionally, private and Catholic schools were also sampled more to support comparisons with public schools. Student surveys collected information on demographics, school activities, student experiences with their native language, income, work-related items, family experiences, and students' beliefs and opinions about themselves (ELS: Questionnaires, n.d.).

The first follow-up survey was administered in 2004, when most of the original students were seniors in high school. Approximately 12,400 students responded, whereby NCES surveyed enrolled students, students who transferred (1,100 students), dropouts and early completers (1,300 students), and school administrators. The sample was also “freshened” to include spring-term 2004 seniors who were not sophomores in their 2002 term; they were given a chance at selection to help maintain the nationally representative cohort (ELS: Survey Design and Samples, n.d.). Information collected for this survey included school experiences and activities, how students spend their time, plans and expectations for the future, potential future education goals, work after high school graduation, and engagement with community/family/friends (ELS: Questionnaires, n.d.). High school transcripts were also collected from students' schools, which included base-year and transfer institutions. These provided information from Grades 9 to 12, including academic grades, courses completed, attendance, and standardized test scores (ELS: Survey Design and Samples, n.d.).

The second follow-up survey was conducted in 2006, when many respondents from the base-year and first follow-up questionnaires were in college or employed after high school graduation. Information for this survey was collected online, by phone interviews, or by personal interview (ELS: Survey Design and Samples, n.d.). Included in this survey was information on college attendance, financial assistance, and degree majors. The study also requested information on employment and civic engagement (ELS: Questionnaires, n.d.). The final follow-up survey was conducted in 2012. Relevant to college persistence, this survey requested retrospective data on college enrollment, degrees earned, and participation in academic and social activities during the postsecondary experience (ELS: Questionnaires, n.d.). The survey also collected information on employment, marital/familial status, and participation in the community. Additionally, NCES collected postsecondary transcripts showing courses completed and financial aid data.

Spanning four waves of data collection over a 10-year period, information from ELS:2002 contains necessary and significant variables for this study, which include demographic information for sex and race/ethnicity, financial assistance, social and academic engagement, achievement growth over time, chosen academic disciplines, GPA, and persistence/dropout outcomes. Therefore, given the many variables applicable to two-factor theory, this dataset provides a few significant advantages to the current study. First, it provides access to a nationally representative distribution of traditionally aged college students (approximately 17-22 years old). Second, using the ELS dataset allows for the study to account for two-factor theory variables that may predict three distinctive categories of the persistence outcome: persistence by staying in a STEM major, changing to a non-STEM major, and dropout from postsecondary education. The third advantage is that the ELS allows for a test of student persistence at multiple institutions, rather than the narrower outcome of retention at a single institution, as the dataset accounts for students who chose to leave an institution to study at different one.

ELS:2002 is better when compared with other datasets, such as the College Senior Survey (CSS) conducted by the Higher Education Research Institute (HERI), based at the University of California, Los Angeles, and federal datasets from the Beginning Postsecondary Students (BPS) longitudinal study and the High School Longitudinal Study (HSLS). While the HERI dataset has more variables useful for testing motivator factors than ELS, it cannot provide significant information about student attrition, fewer than 100 institutions participate in the study, and the response rate is lower than ELS:2002 (S. Hurtado, personal communication, November 6, 2017). In addition, access to HERI data is limited, as only the most recent study (from 2007) is available to researchers and contains data that is five years older than the ELS data.

On the other hand, BPS does have more recent data, drawn from a cohort measured during the students' junior year in 2014, and like ELS:2002, is a national longitudinal study. It does not, however, contain variables for motivator factors, nor does it address degree completion, making it unsuitable for this study. In addition, the HSLS is in the process of following ninth-grade high school students into their junior year of college, with a second follow-up survey released in 2016. This study may have the potential to provide more current information, but the latest dataset does not provide complete persistence information and contains limited variables suitable for this study. Therefore, ELS is an optimal data source for testing two-factor theory because it can provide results for a relatively recent cohort on a national scale and contains relevant variables to test STEM student persistence through both hygiene and motivator factors.

Sample

This study focused on a sample representing those students from the ELS:2002 BY survey who attended a U.S. four-year postsecondary institution, indicated an interest in pursuing a STEM bachelor's degree on the F2 survey, and reported their degree outcome in the F3 survey in 2012. Selection for this sample was determined by those students who chose a STEM-related major as described by the F2 survey variable labeled *Field of study most likely to select upon entering college*. Starting with a dataset of 15,400 respondents from the BY survey, this reduced the sample size to 1,390 students who attended a four-year institution and indicated interest in a STEM major at the start of college at the time of the F2 survey. Field of study categories for this variable were based on NCES's CIP codes.

Dependent Variable

The STEM persistence outcome is composed of three distinctive categories: (a) no degree, (b) earning a non-STEM undergraduate degree, and (c) earning a STEM undergraduate degree. The outcome is based on an undergraduate degree earned since the F2 survey in 2006 across all institutions that the student attended as indicated by the F3 survey in 2012. The distinction between these three categories may provide a deeper understanding of how two-factor theory variables may predict STEM student persistence, as well as potential differential relationships by sex and race/ethnicity. As such, this study requires a multinomial dependent variable representing the three outcome categories. Table 3.1 provides a description of the three dependent variable categories and their respective values.

Table 3.1
Description of Dependent Variable and Measure

Variable	***Scale***
STEM Persistence	1=no degree; 2=non-STEM degree; 3=STEM degree

To test the outcome, this study required the creation of a new variable for STEM persistence in a bachelor's degree program using existing variables, as this does not exist in the ELS:2002 dataset. The category to represent persistence in a STEM degree was generated from a composite of two ELS variables from the F3 survey, *First known bachelor's degree major* and *Most recent known bachelor's degree major*. The use of both variables was necessary to capture any STEM degrees students have earned since their first year of college. The degree majors indicated in these variables that fall within STEM disciplines were combined to create the referent outcome category, called *STEM degree*, categorized with a value of 3. This value was chosen for the STEM degree outcome because the statistical program used for this study, Stata, treats the last category as the referent group, which allows for the other two categories to be compared to the STEM degree outcome. For this study, double majors with at least one STEM undergraduate degree earned were treated as a STEM degree.

Likewise, *First known bachelor's degree major* and *Most recent known bachelor's degree major* were used to create a comparative outcome to the STEM degree outcome, called *non-STEM degree*, to combine any degree majors that do not fall under the STEM disciplinary categories. This outcome was categorized with a value of 2. Finally, the third outcome from the F3 survey, *No degree*, was generated with a value of 1 by selecting those respondents in the composite variable who did not earn an undergraduate degree, which distinguishes those who did not achieve a STEM degree due to dropout rather than changing majors to a non-STEM degree.

Independent Variables

Independent variables were organized into three variable sets using two-factor theory as the conceptual framework: (1) demographic factors, (2) hygiene factors, and (3) motivator factors. Using hierarchical linear regression, block entry 1 used demographic variables and hygiene factors first to test their relationship with STEM persistence. A second model incorporated variables identified to be motivator factors along with demographic and hygiene factor variables in block entry 2 and was tested to see if the model improved. This section identifies and explains the use of all independent variables for the study.

Demographic factors.

As reviewed in the previous literature, persistence in STEM can vary by sex and race/ethnicity. Previous research has revealed a tendency for women, black students, and Hispanic students to leave their STEM programs more than men, Asian students, and white students. There are also differences in departure, with more men leaving STEM by institutional dropout, whereas women tend to leave STEM by switching majors (Chen, 2013). Demographic variables as predictors have also been shown to be moderated by the inclusion of other interaction variables, such as participation in undergraduate research (Chang et al., 2014; Espinosa, 2011; Xu, 2016). As this study examined differences in STEM persistence in sex and race/ethnicity, variables representing these factors were included in all block-entry models to investigate how predictors may influence STEM persistence by sex and race/ethnicity.

This study used the ELS variables for sex and race/ethnicity from F1 survey data to examine their effect on STEM persistence and the interaction of predictors on demographics. F1 observations were chosen over BY due to the availability of complete demographic data in the F1 survey, whereas the BY data lack complete data regarding sex and race/ethnicity. The variable for sex was recoded as a new variable called *female* so that the response value for female is represented by a 1, and the response value for male is represented by 0. Recoding in this way allowed for the male category to be used as a reference group and to test the persistence of female students in the block-entry models. Likewise, race and ethnicity categories were recoded into separate dummy variables from the ELS variable for race. ELS:2002 used the following categories to indicate race/ethnicity: American Indian/Alaska Native, Asian/Hawaiian/Pacific Islander, black or African American, Hispanic (no race specified), Hispanic (race specified), multiracial, and white. The Hispanic categories were merged to examine the STEM persistence experience of all Hispanic students as a combined population in this sample. The categories for American Indian and multiracial were combined due to insufficient representation in the sample, which may negatively affect standard errors if included as separate categories. White students are the referent group in this study and therefore excluded from the model. The values for each race variable were coded as a value of 1 for yes (meaning that the respondent identified as that race/ethnicity) and 0 for no (not of that race/ethnicity). Table 3.2 provides a detailed listing of demographic variables and measures that were used in this study for sex and race/ethnicity.

Table 3.2

Description of Demographic Variables and Measures

Variable	*Scale*
Female	1=female; 0=male
Asian	1=yes; 0=no
Black	1=yes; 0=no
Hispanic	1=yes; 0=no
Multiracial	1=yes; 0=no

Hygiene factors.

Along with demographic factors, variables for hygiene factors were entered in the first block of the regression analysis. Specific categories from two-factor theory were relabeled to better represent STEM persistence categories: *supervision* was renamed *academic advisement*, *work conditions* became *academic environment*, and *salary* became *financial assistance*. The remaining categories of hygiene factors, *interpersonal relationships* and *personal life*, remained the same. Variables under each category with more than two responses (for example, often, sometimes, and never) were converted into binary dummy variables to accommodate multiple imputation. A detailed list of the hygiene factor variables and scales for each is listed in Table 3.3 at the end of this section.

In the first hygiene category, interpersonal relationships were represented by two ELS:2002 variables addressing academic and social integration from previous literature. The factors of interpersonal relationships are represented by the variables *Talking with faculty about academics outside of class* and *Participation in extracurricular activities*. Since these variables have a limited number of cases in the sample and have three response categories (never, sometimes, and often), each response was recoded as one of two binary dummy variables, with values of 1 for yes, combining responses for sometimes and often, and 0 for no, representing never. Recoding in this way helped simplify multiple imputation (to be discussed later in this chapter) and eliminated perfect prediction errors that occur due to a lack of variation in smaller samples.

Furthermore, the second hygiene factor category, academic advisement, substitutes for supervision due to the similar relationship that advisors may have with their students as compared with supervisors and their employees. This category is therefore represented by the ELS variable *Meeting with advisor about academic plans*. This variable was also recoded as a binary dummy variable representing responses for yes and no.

The third hygiene category, academic environment, serves as a proxy for working conditions and represents the educational climate that STEM students may experience. Past research suggests that academic environment and selectivity of the institution can affect persistence (Chang et al., 2008; Chen, 2013; Chinn, 1999; NASEM, 2016). Therefore, institutional selectivity is represented by *Highest selectivity among all attended postsecondary institutions*. This variable—categorized by high selectivity, moderate selectivity, inclusive selectivity, and unclassified selectivity—was recoded with a value of 1 representing high selectivity and 0 for all other selectivity categories.

ELS:2002 also provides two variables related to the category of personal life: *Parents' highest level of education* and *Lived with parents in spring 2006*. Herzberg et al. (1959) intended this category to mean the effect that work may have on employees' personal lives, thereby affecting their satisfaction with the job. Looking at persistence research, factors related to the personal life of a student, such as parents' education and commuting from home are known to affect persistence (Lamont & Lareau, 1988; Turley, 2006; Wells, 2009). While these variables imply an impact on the college experience and persistence, one cannot infer that the relationship between the student's education and personals factors are one-way. Presumably, students' pursuit of education may also affect the personal issues they are experiencing, thereby mutually impacting both sides of the persistence issue. These variables remain as is, with values for yes equal to 1 and no equal to 0.

The final hygiene factor category to be tested, *financial assistance*, relates to financial variables to pay for education. As discussed in the conceptual framework section, this factor may have similar characteristics to salary in how it may affect student persistence. For financial factors, financial aid and the ability to pay for education can help the student to persist, but that characteristic's ability to impact persistence further may taper once the student is financially stable. Multiple variables in ELS:2002 are connected to this factor, and therefore, included in binary form in the study as they are: *Postsecondary education paid with grants/scholarships*; *college work-study*, and *family contribution*. Data for these variables were taken from the F2 survey, representing responses collected during the second year of college for most respondents. Response categories for these variables remain the same, with yes equal to 1 and no equal to 0.

Another variable relevant to this category, *Proportion of tuition and fees paid by grants/scholarships in the first term* is also included. This variable is categorical in its original form in the ELS:2002 dataset and was recoded as three binary dummy variables, with 1 equal to yes and 0 equal to no. These variables are *All of tuition and fees paid by grants/scholarships in the first term*; *At least half of tuition and fees paid by grants/scholarships in the first term*; and *Less than half of tuition and fees paid by grants/scholarships*. The category *Tuition and fees not paid by grants/scholarships in the first term* is the referent group and is excluded from the model.

Finally, the variable *Total amount borrowed in student loans* is also included in this study, representing all student loans borrowed since high school, excluding loans taken out by parents. I chose this variable after some consideration of categorical loan variables from the F2 survey, representing the first through second year of college. While the timing of the categorical variables made it suitable for predicting STEM persistence later in the college experience, their discrete nature would provide limited information in the regression model as compared to a continuous variable. Loan amount, however, is the only continuous variable for financial aid in the ELS:2002 public dataset, which provided a more accurate measure to predict the effect of loans on the persistence outcome. This variable is continuous, and the results are scaled in $1000 increments with dollar amounts starting at 0 up to 300,000.

Table 3.3
Description of Hygiene Factors and Measures

Variable	*Scale*
Interpersonal Relationships	
Talking with faculty about academics outside of class (as of 2nd year)	1=yes; 0=no
Participation in extracurricular activities (as of 2nd year)	1=yes; 0=no
Academic Advisement	
Meeting with advisor about academic plans (as of 2nd year)	1=yes; 0=no
Academic Environment	
High selectivity (first known postsecondary institution)	1=yes; 0=no
Personal Life	
Parent education: 4-year degree or higher	1=yes; 0=no
Lived with parents in spring 2006	1=yes; 0=no
Financial Assistance	
All of tuition/fees paid for by grants/scholarships in first term	1=yes; 0=no

At least half of tuition/fees paid for by grants/scholarships in first term	1=yes; 0=no
Less than half of tuition/fees paid for by grants/scholarships in first term	1=yes; 0=no
Grants/scholarships (as of 2nd year)	1=yes; 0=no
Work study (as of 2nd year)	1=yes; 0=no
Family contribution (as of 2nd year)	1=yes; 0=no
Loan amount ($1000 increments, post-college)	0 – 300,000

Motivator factors.

This study also tested factors related to activities that can intrinsically motivate STEM students, mostly in the form of high-impact educational practices and GPA. The variables representing high-impact educational practices are activities that students may have done at any point in college. Since some activities may have occurred in the junior or senior year of college, they may be highly correlated with graduation. A simple correlation matrix was generated in Stata between motivator factors and the outcome variable to ensure their suitability for the study (see Appendix). A correlation of one (1.0) would indicate a perfect correlation; therefore, a value close to one represents high correlation between two factors. The appendix shows that the highest correlation is between total GPA and the degree outcome, though indicating only a moderate correlation (.46). The next highest correlation is GPA in the first year (.38), followed by internships/co-ops (.34). The lowest correlations are between degree outcome and the remaining motivator factors: undergraduate research (.26), study abroad (.18), service learning (.10), and mentorship (.09). Given the low correlation of the motivator factors and the degree outcome variable, all motivator factors were included in the study. Furthermore, while the ELS variables related to motivator factors may overlap into multiple categories, block entry 2 included two-factor theory variables representing *the work itself*, *responsibility, recognition,* *opportunities for growth,* and *achievement*. A table of all motivator factor variables and scales is listed in Table 3.4 at the end of this section.

The first two motivator factor categories, the work itself and responsibility, incorporated a variable for participation in undergraduate research. As previous literature demonstrates, STEM students who engage in undergraduate research with faculty are more likely to persist, as it engages students in a discipline of their interest (Dancy & Henderson, 2010; Espinosa, 2011; Kuh, 2008; Xu, 2016). Therefore, research is an appropriate variable to represent intrinsic motivation because it enables students to participate in academic work that the students finds satisfying and provides validation of the student's potential in STEM from faculty members. The corresponding ELS variable for this study is *Research project with a faculty member outside course/program requirements*. Participation in internships has a similar impact in connection to the work itself, as it directly engages students in work related to their academic interests (Kuh et al., 2008). The corresponding variables from the ELS dataset are *Internship/co-op/field experience*, which was used for this study. These variables remain as they are, with response values for yes represented by 1 and no represented by 0.

One issue of concern for this study is that involvement in research and internships may occur in advanced years of college, thereby making participation highly associated with persistence to degree completion. While a simple correlation matrix revealed no evidence of multicollinearity or a high level of association of research and internships/co-ops with the STEM persistence outcome, additional support for using internships and research variables as motivator factors may be needed. While there appear to be few studies or national reports indicating when students are likely to participate in these types of activities, some insight may be gleaned from a 2012 report from the National Association of Colleges and Employers (NACE). NACE annually collects internship and co-op data, and in 2012, collected information from 2,965 students of 280 member-organizations across the United States, the same year that ELS:2002 data was completed. The report showed that the highest percentage of students participated in internships and co-ops in their junior year at 33%, followed by seniors at 27%. Sophomores made up the third greatest percentage at 24%, followed by freshmen at 16% (NACE Research, 2012). Although this may not be statistically representative of all nationwide college students in 2012, it does show that 40% of its survey respondents chose to participate in internships and co-ops early in their college experience. Subsequently, there may be other reasons for the significance of these variables beyond when students chose to participate, thereby making research and internships suitable factors to include in the persistence model.

While a case can be made for all high-impact practices to be opportunities for growth, this is especially true for study abroad opportunities and community-based projects, such as service-learning activities. These types of experiences, like other high-impact educational practices, are known to provide substantial growth opportunities through activities that foster deep learning (Kuh, 2008). Therefore, the ELS variables that are respectively used for these two categories are *Study abroad* and *Community-based projects/Service learning*. As with the previous variables, these remain with their current response categories, with yes equal to 1 and no equal to 0.

The next motivator factor category tested in this study is recognition. This factor is unique in that the studies by Herzberg et al. (1959) and Carlone and Johnson's (2007) science identity both named this specifically as a crucial attribute reflecting positive experiences shared by their respective research participants. Thus, the ELS variable that represents recognition is *Mentorin*g; the act of mentoring is an indication that an authority who is significant to the student's chosen discipline recognizes the academic potential in the student through a willingness to work with the student, thereby fostering the student's science identity (Carlone & Johnson, 2007). This variable remains the same, with response categories for yes represented by 1 and no represented by 0.

In the category for achievement, GPA is included here because it represents grades and credits earned from the student's effort. While GPA shares some characteristics with receiving pay for work, making it a potential variable as a hygiene factor, it can also be a representation of a sense of achievement. Two-factor theory treats salary as a hygiene factor due to its association with dissatisfactory pay, but in some instances, salary in the form of a raise or bonus can be associated with a sense of achievement in recognition of the individual's work (Herzberg et al., 1959). Previous literature has generally shown high GPA to be associated with STEM persistence, specifically at 3.0 or higher (Chen, 2013), but some students with high GPAs, particularly women and URMs, change majors when the STEM academic environment is unsupportive (Borrego et al., 2005; Brainard and Carlin, 1998; Espinosa, 2011). This study treats GPA as a motivator factor, assuming that a higher GPA may be connected to intrinsic motivation. The relevant ELS variables related to this factor are *GPA at all known institutions attended* and *GPA in the first year of known attendance*. These variables were added into the model to test their respective significance for STEM persistence and examine interaction effects with women and specific race/ethnicity categories. As they are continuous, these variables have remained in this form to understand their impact fully as predictors on the persistence outcome.

Table 3.4
Description of Motivator Factors and Measures. All variables are from F3 survey in 2012.

Variable	***Scale***

The work itself/Responsibility	
Research project with faculty member outside course	1=yes; 0=no
Internship/co-op/field experience	1=yes; 0=no
Opportunity for Growth	
Study abroad	1=yes; 0=no
Community-based project/Service learning	1=yes; 0=no
Recognition	
Mentoring	1=yes; 0=no
Achievement	
GPA in first year	0.0 - 4.0
Overall GPA	0.0 - 4.0

Data Analysis

Given the categorical nature of the outcome variable, (1) persistence in a STEM major to degree completion, (2) switching to a non-STEM major and completing a non-STEM degree, and (3) no degree due to dropout from the postsecondary institution, this study used multinomial logistic regression to answer the research questions. The main effects of STEM persistence by demographics and hygiene factors were tested first using a block-entry method, and then a second model was tested, incorporating motivator factors in a final block. Next, the addition of variables representing motivator factors was tested using a post-estimation test. By comparing the model with and without motivator factors, this study sought to understand whether incorporating motivator factors can significantly improve the model and explain the STEM persistence outcome. Finally, in addition to testing the main effects from the hierarchical model, a model with interaction terms was tested to investigate whether the relationship between hygiene and motivator factors and STEM persistence is significantly different across different sex and race/ethnicity groups.

Interaction terms.

As indicated above, this study included and tested interaction terms to explore differential effects of the hygiene and motivator factors across sex and race/ethnicity. Previous research demonstrated compensatory effects of high-impact practices, particularly undergraduate research, on persistence. This effect was pronounced for women and URMs, making specific sex and race/ethnicity appropriate factors for testing interaction terms with motivator factors. The inclusion of this process avoided main effects bias, whereby predictors are assumed to impact the outcome in the same manner regardless of the student's background (Chen, 2003; Jaccard, 2001). Testing for interaction effects corrected this bias by testing how sex and race/ethnicity modify the relationship between significant predictors and the persistence outcome, thereby helping policymakers and postsecondary institutional leaders target interventions to improve STEM persistence for specific student subgroups.

Multiple imputation.

Stata, which was used to run the models, includes the capability of multiple imputation for missing data in the dataset. Multiple imputation has the advantage of avoiding statistical issues associated with other imputation methods, can be used for various regression procedures, and can produce unbiased statistical estimates and yield accurate standard errors when conducted properly (Allison, 2001; Schafer & Graham, 2002). The multiple imputation method involves filling in missing values several times to create multiple completed datasets based on the observed values for the respondent and the observed connection to other similar respondents in the data sample (Schafer & Graham, 2002).

Following the current standard practice for imputation, 25 datasets were run to impute missing data for this study, consisting of a sample size of 1,319. Of the 27 variables included in this study, 20 variables had missing values. Of the variables that had missing observations, approximately 4% of the data required multiple imputation. This ranged from two missing values from the variables of faculty interaction and academic advisement up to 93 observations for first-year GPA. Moreover, as noted earlier, several of the variables were simplified into binary, dummy variables to prevent perfect predictor errors during multiple imputation. Perfect predictor errors occur when there is a lack of variation in the observed data of the sample. Given the size of the sample (n=1,319), multinomial categorical variables in this sample were prone to perfect predictor errors since a limited number of students may be represented for each variable category. Therefore, recoding these variables into binary categorical variables optimized the process of multiple imputation.

Weight adjustment.

In addition to imputation, sampling weights were also considered. Panel weights were used at each step of the ELS:2002 study to correct probability estimates, as various types of respondents had unequal representation in the study. Weighting corrected for this by creating unbiased probabilities for various subsets in the population, which would otherwise generate distorted results. Since the final sample for this study involved participants who participated in all four survey waves (BY, F1, F2, and F3), the panel weight variable, F3BYPNLWT, was incorporated into the regression analysis and normalized by calculating the average of the response panel weight and dividing by the panel weight.

Limitations.

The limitations of this study were inherent in the use of the ELS:2002 dataset for secondary data analysis. One limitation was the number of variables available to test the two-factor theoretical construct. Variables for the hygiene categories for policies, status, and security, as well as the motivator factor category for advancement do not exist within the ELS dataset. However, the other chosen variables for this study cover most of the conceptual framework's categories, providing an initial foundation for testing the utility of two-factor theory and a basis for testing the theory further.

Moreover, there is a limitation in understanding the psychological nature of the variables chosen for motivator factors. The intrinsically motivating nature of these variables was deduced through previous studies because the original F3 survey does not explicitly examine the attitudes of the students regarding these specific activities. Since most of motivator factor variables are considered to be high-impact educational practices, credibility as intrinsically motivating factors come from past literature, which Kuh et al. (2008) describe as the compensatory quality of these practices that overcome student obstacles to academic success. Moreover, GPA is also used as a proxy for sense of achievement. ELS:2002 has no variable confirming whether earning high grades generates feelings of achievement; however, GPA is used in this test for its historical indication of academic achievement in previous retention and persistence research. Therefore, given these characteristics, these variables were reasonably included as suitable proxies for motivator factor categories.

Another limitation is the use of variables measuring a student's experience of the STEM academic climate. This study used the level of selectivity of the institution rather than specific STEM environments (such as classrooms, laboratories, academic departments) and general factors that impact persistence. However, given the experience of STEM students from previous literature, it may not be realistic to parse out the STEM experience from the overall college experience, as the daily life of STEM students is entwined with the campus interactions that they experience. Therefore, it was sufficient to use institutional selectivity as a means to understand one aspect of the educational environment associated with persistence.

Despite these limitations, this study provides a solid foundation for understanding STEM student persistence through two-factor theory for the first time in a research study. As an initial study to test this conceptual framework, the groundwork established here can provide educators and policymakers more tailored knowledge of the needs of STEM students and their persistence in college. It also provides a basis for researchers to examine the utility of intrinsic motivation of STEM students and the educational activities that can bolster this motivation within themselves toward success.

Chapter Four: Results

The purpose of this study is to examine how hygiene and motivator factors predict STEM persistence among undergraduate students and how those relationships may vary by sex and race/ethnicity. As discussed in Chapter 3, the analytical sample for this study is composed of students from ELS:2002 who specifically indicated their interest in pursuing a STEM major in their senior year of high school in the first follow-up survey in 2004, participated in subsequent follow-up survey in 2006, and provided their STEM persistence outcome in final follow-up survey in 2012. Revisiting the research questions for this study, I seek to understand the following:

1. What is the persistence rate among STEM major students? Are there any sex and racial differences?
2. How do hygiene factors predict STEM student persistence?
3. How do motivator factors improve our understanding of STEM student persistence beyond the model with hygiene factors?
4. Do the relationships between motivator factors and STEM student persistence vary significantly across sex and race/ethnicity?

To answer the first research question, descriptive statistics are reported in this chapter with frequency distributions and cross-tabulations. The remaining questions are answered in three steps. Question two is answered by the results of an initial multinomial logistic regression block-entry analysis of demographic and hygiene factor variables regressed on the STEM persistence outcome in three possible categories measured by (1) no degree, (2) non-STEM degree, and (3) STEM degree. The third research question is addressed by a second block-entry model testing the effect of motivator factors on the STEM persistence outcome beyond hygiene factors, followed by a post-estimation test on the additional variables to examine if they improve the model. Addressing the final research question, a final set of tests is then reported that analyzes potential interaction effects between significant motivator factors and sex, as well as between motivator factors and race/ethnicity.

Descriptive Statistics

Table 4.1 provides descriptive information for the variables chosen for this study from the ELS:2002 dataset. The table indicates either the represented percentage for categorical variables of the sample or the mean for continuous variables. It also provides the standard error (SE) and minimum and maximum coded values for dummy variables and minimum and maximum values for continuous variables. The sample size is 1,319, which was determined by choosing variables for students who intended to enter college with a STEM major as indicated on the F2 survey in 2004, attended one or more four-year institutions, and reported their undergraduate persistence outcome as of the F3 survey in 2012. The first variable is the outcome variable, representing the three measured outcomes: (1) no degree, (2) non-STEM degree, and (3) STEM degree. Addressing the first part of the initial research question (*What is the persistence rate among STEM major students?*), this sample consists of 30% of students who did not earn a degree by the F3 survey, 29% who switched majors to earn a non-STEM degree, and 41% who persisted to earn a STEM degree.

The next set of variables represents demographics, organized by sex and race/ethnicity. It should be noted that students in the base-year survey had the opportunity to identify multiple categories of race and ethnicity, and the opportunity to indicate Hispanic was a separate survey item from the question to identify by race. Regarding sex, 30% of the respondents were female, while 70% were male. For race/ethnicity, 16% were Asian, 13% were black, 9% identified as

Hispanic, 59% were white, and 4% were labeled in this study as "other race," representing a combination of Native American students and students indicating more than one race. This category is combined, as a relatively small number of students are represented in the sample.

In keeping with two-factor theory, the next set of variables is organized by hygiene factors, represented by the following categories: interpersonal relationships, academic advisement, academic climate, personal life, and financial assistance. The category of interpersonal relationships is represented by two variables, students who interacted with faculty outside the classroom (25%) and participation in extracurricular activities (37%). The category of academic advisement is denoted by the variable for meeting with an advisor (88%). Moreover, several variables were related to financial assistance. The first four variables indicated the proportion of tuition and fees covered by grants and scholarships in the first academic term: all tuition and fees covered (19%), at least half covered (19%), less than half covered (27%), and no tuition and fees covered by grants/scholarships (35%). The next three variables are categorical variables that indicate whether or not a student received specific kinds of financial assistance. These are grants/scholarships (64%), work-study (14%), and family contribution (60%). The final variable under the salary category is a continuous variable indicating the total college loan amount. The mean for loan amount is $25,620, with a minimum of $0 and a maximum of $300,000, with 65% of the sample borrowing loans. Moreover, one variable for academic environment is represented by high institutional selectivity (40%). The final category for hygiene factors is personal life. This category is represented by two variables: having at least one parent with a four-year degree (61%) and living with parents (30%).

The final set of variables falls under motivator factors. Motivator factors are organized as follows: the work itself/responsibility, opportunity for growth, recognition, and achievement.

Two variables fall under the category for the work itself/responsibility: students who conducted research with a faculty member outside the classroom (23%) and those who took part in internships and co-ops (51%). Under opportunity for growth, there are two variables: students who participated in community-based projects/service learning (18%) and students with study abroad experiences (10%). Moreover, the variable corresponding with the category of recognition is whether a student received mentorship (18%). For the final category, achievement, there are two continuous variables, GPA in the first year of study and overall GPA. The mean for first-year GPA is 2.8, while the mean for total GPA is 2.9.

Table 4.1 *Descriptive Statistics of Outcome, Demographic, Hygiene Factor, and Motivator Factor Variables*

ELS: 2002 (n=1,319)

Variable	**Proportion/ Mean**	**SE**	**Min.**	**Max.**
Outcome				
No Degree	0.30	(0.01)	-	-
Non-STEM Degree	0.29	(0.01)	-	-
STEM Degree	0.41	(0.01)	-	-
Demographics				
Sex				
Female	0.30	(0.01)	0	1
Male	0.70	(0.01)	0	1
Race/Ethnicity				
Asian	0.16	(0.01)	0	1
Black	0.13	(0.01)	0	1
Hispanic	0.09	(0.01)	0	1
Other Race	0.04	(0.01)	0	1
White	0.58	(0.01)	0	1
Hygiene Factors				
Interpersonal Relationships				

Faculty interaction outside classroom	0.25	(0.01)	0	1
Extracurricular activities	0.37	(0.01)	0	1
Academic Advisement				
Meeting with advisor	0.88	(0.01)	0	1
Financial Assistance				
All tuition/fees paid by Grants/scholarships in first term	0.19	(0.01)	0	1
At least half of tuition/fees paid by grants/scholarships in first term	0.19	(0.01)	0	1
Less than half of tuition/ fees paid by grants/ scholarships in first term	0.27	(0.01)	0	1
Tuition/fees not paid for by grants/scholarships in first term	0.35	(0.01)	0	1
Grants & scholarships	0.64	(0.01)	0	1
Work-study	0.15	(0.01)	0	1
Family contribution	0.60	(0.01)	0	1
Loan amount *	25,616.15	(1,116.51)	0	300,000
Academic Environment				
High institutional selectivity	0.40	(0.01)	0	1
Personal Life				
Parent with a 4-year degree	0.61	(0.01)	0	1
Lives with parent(s)	0.30	(0.01)	0	1
Motivator Factors				
The work itself/Responsibility				
Research with a faculty member	0.23	(0.01)	0	1
Internship/Co-op	0.51	(0.01)	0	1
Opportunity for growth				
Service learning	0.18	(0.01)	0	1
Study Abroad	0.10	(0.01)	0	1
Recognition				
Mentorship	0.18	(0.01)	0	1

Achievement				
GPA in first year*	2.78	(0.03)	0	4
Total GPA*	2.87	(0.02)	0	4

**continuous variable*

Persistence Rates by Sex & Race/Ethnicity

Beyond the descriptive statistics for each variable, this study examines the persistence rates by sex and race/ethnicity. To answer the second part of research question one (*Are there any sex and racial differences?*), persistence percentage rates are estimated post-multiple imputation for sex and each race/ethnicity variable with the STEM degree outcome variable reported to the nearest hundredths (values may not total 100% due to rounding). Table 4.2 provides a summary of the persistence rates for each outcome by sex and race/ethnicity (rounded to the nearest hundredths). An examination of persistence rates by sex shows that 32% of males who intended to study in a STEM major did not complete a degree. Furthermore, 26% of males changed majors to a non-STEM degree. The remaining 43% of males successfully completed a STEM undergraduate degree. Compared to males, degree incompletion among female students is less prevalent at 25%; however, 38% of females switched to a non-STEM major instead, a 13% difference. Finally, 37% of females persisted to STEM degree completion, 6% lower than the male STEM persistence rate.

As of race/ethnicity, 21% of Asian students did not complete a degree, while 25% switched to a non-STEM major. Asian students have the highest STEM persistence rate, with 54% completing a STEM major. Of all racial/ethnic student groups, blacks have the highest incompletion rate at 52%, while another 23% changed to a non-STEM major. Black students have among the lowest STEM persistence rates at 24%. Hispanic students also have a relatively high degree incompletion rate at 41%. Another 29% of Hispanics switched majors to a non-

STEM degree, while the remaining 30% persisted to STEM degree completion. In the smallest category, which combines Native Americans and multiracial individuals, students of other races had a 28% rate of degree incompletion, while 34% switched to a non-STEM degree. The remaining 38% persisted to STEM degree completion. Finally, among white students, 25% did not complete a degree, 32% switched to a non-STEM major, and 43% persisted to STEM degree completion.

Table 4.2 *Descriptive Statistics of STEM Persistence Outcome by Sex and Race/ethnicity*
ELS: 2002 (n=1,319)

Variable	No Degree	SE	Non-STEM	SE	STEM	SE
Female	0.25	(0.02)	0.38	(0.02)	0.37	(0.02)
Male	0.32	(0.02)	0.26	(0.01)	0.43	(0.02)
Asian	0.21	(0.03)	0.25	(0.03)	0.54	(0.04)
Black	0.52	(0.04)	0.23	(0.03)	0.24	(0.03)
Hispanic	0.41	(0.05)	0.29	(0.04)	0.30	(0.04)
Other Race	0.28	(0.06)	0.34	(0.06)	0.38	(0.07)
White	0.25	(0.02)	0.32	(0.02)	0.43	(0.02)

Note: Proportions for each variable may not equal 1 due to rounding.

Model 1: Demographics & Hygiene Factors

As discussed in earlier chapters, hygiene factors are extrinsic factors associated with worker dissatisfaction. This study substitutes hygiene factors of worker dissatisfaction with proxies for equivalent STEM student persistence variables from known theories and previous research. In response to the second research question (*How do hygiene factors predict STEM student persistence?*), the results of a second model testing the main effects of sex and demographics combined with hygiene factors are discussed in this section (see Table 4.3). Moreover, while reporting odds ratios is common in education research, Stata uses relative risk ratios (RRR) to calculate the probability ratio of a multinomial outcome when using multiple imputed data. RRR represents the likely risk of an outcome in the comparison group as compared with the risk of the referent outcome, represented by the estimated exponentiated B coefficient [exp(B)]. An RRR greater than one (RRR>1) indicates that the comparison outcome will be more likely, represented by a factor or percentage increase. An RRR less than one (RRR<1) indicates the outcome to be more likely in the referent group, represented by a factor or percentage decrease. Additionally, it should be noted that earning a STEM degree is the reference outcome that the other two outcomes, no degree and non-STEM degree, are compared with in this study. Therefore, any positive or negative relationships are reported in relation to the no degree and non-degree outcomes.

Additionally, a simple correlation matrix was generated prior to testing the models to check for multicollinearity between any variables in the study (see Appendix). With 1 representing a perfect correlation, the highest correlation was found between first-year GPA and total GPA (0.67), but this is a moderate correlation at best. As none of the variables showed high correlation with one another, all variables chosen for the study were included in subsequent tests.

In examining the main effects of sex, female students who did not complete a degree show no statistical significance as compared to males, while the relative risk for females who complete a non-STEM degree increases by a factor of 2.02 (102% more likely, $p<.001$) as compared to STEM degree recipients, holding all other variables constant. As with race/ethnicity, Asian students show no statistical significance with being less likely to drop out to a non-STEM degree, but Asians show a negative association with earning a non-STEM degree, decreasing by a factor of .41 ($p<.05$). Black students are significantly associated with no degree with a relative risk increasing by a factor of 4.22 ($p<.001$), as well as showing a significant relative risk with completing a non-STEM degree as compared to STEM degree recipients by a factor of 2.73 (p<.001). Hispanics and students of other races are insignificant predictors of STEM persistence.

Moving on to hygiene factors, the first category of interpersonal relationships may have some relevance to STEM persistence. Holding all other variables constant, the variable for faculty interaction outside the classroom indicates no significance for students who did not complete their degree. However, there is a statistically significant negative association with a non-STEM degree outcome with a relative risk decreasing by a factor of .50 (p<.001). The negative correlation with switching to a non-STEM major may indicate the importance of faculty-student relationships that are associated with STEM persistence. However, participation in extracurricular activities has no statistical significance with either a non-degree or non-STEM degree outcome. Furthermore, in the category for academic advisement, the variable for meeting with an advisor displays no significant results for either a non-degree or a non-STEM degree outcome.

However, under the category for financial assistance (as represented by different forms of financial aid and the ability to pay for tuition), there are some substantial findings. The first three variables in this category represent the proportion of tuition and fees paid by grants and scholarships in the first academic term. The three variables are all of tuition and fees paid, at least half of tuition and fees paid, and less than half of tuition and fees paid. The model demonstrates that students who had all or at least half of their tuition paid by grants and scholarships in the first term are less likely to have no degree by a factor decrease of .67 (p<.001) and .66 (p<.01) respectively. However, these variables show no statistically significant relationship to non-STEM degree completion in comparison with STEM degree recipients. In addition, the variable for receiving grants and scholarships covering less than half of tuition and fees shows no significant association with either the no-degree outcome or earning a non-STEM degree as compared with earning a STEM degree.

The next three variables under financial assistance are binary and indicate whether the student had specific kinds of financial assistance at the time of the F2 survey (approximately sophomore year of college for most of the respondents). These variables are grants/scholarships, work-study, and family contribution. Grants/scholarships and work-study are not statistically significant for any outcome; however, family contribution decreases the relative risk of no degree by a factor of .34 ($p<.05$). Family contribution is not significant for non-STEM degree students when compared with STEM degree students. The final variable under financial assistance is a continuous variable for the total loan amount borrowed with the values scaled to $1000 increments. Loan amount is significant—for every $1000 increase in loan amount, it decreases the risk of no degree by a factor of .01 ($p<.05$). However, loan amount has no significant association with earning a non-STEM degree as compared to a STEM degree.

Under academic environment, the variable for high selectivity has a negative significance with the non-degree and non-STEM degree outcomes, decreasing by a factor of .75 ($p<.001$) and .37 ($p<.05$) respectively. Under the category of personal life, the variable for having a parent with a four-year degree negatively predicts a no degree outcome by relative risk of .46 ($p<.01$), and the variable for living with parents is positively associated with a no degree outcome by factor of 1.71 ($p<.05$). However, neither variable was significant for the non-STEM degree outcome.

Table 4.3. *Model 1: multinomial regression with demographics and hygiene factors*
ELS: 2002 (n=1,319)

	NO DEGREE			NON-STEM DEGREE		
Variable	**RRR**	**SE**	**Sig.**	**RRR**	**SE**	**Sig.**
Sex						

Female	1.23	(0.27)		2.02	(0.39)	***
Race/Ethnicity						
Asian	0.60	(0.16)		0.59	(0.14)	*
Black	4.22	(1.29)	***	2.73	(0.85)	***
Hispanic	1.63	(0.56)		1.45	(0.50)	
Other race	1.21	(0.60)		1.45	(0.66)	
Interpersonal Relationships						
Faculty interaction	0.78	(0.18)		0.50	(0.10)	***
Extracurricular activities	0.87	(0.17)		1.06	(0.19)	
Academic Advisement						
Meeting with advisor	0.60	(0.18)		0.92	(0.30)	
Financial Assistance						
All tuition/fees paid by grants & scholarships in first term	0.33	(0.11)	***	0.58	(0.18)	
At least half of tuition/fees paid by grants/scholarships in first term	0.34	(0.12)	**	0.71	(0.21)	
Less than half of tuition/ fees paid by grants & scholarships in first term	0.70	(0.20)		0.79	(0.20)	
Grants & scholarships	0.74	(0.18)		0.68	(0.16)	
Work-study	0.97	(0.30)		0.92	(0.25)	
Family contribution	0.66	(0.14)	*	0.98	(0.19)	
Loan amount (scaled to $1000)	999.99	(0.01)	*	1000	(0.00)	
Academic Environment						
High institutional selectivity	0.25	(0.06)	***	0.63	(0.12)	*
Personal Life						
Parent with a 4-year degree	0.54	(0.12)	**	1.02	(0.21)	
Lives with parent(s)	1.71	(0.37)	*	1.04	(0.23)	

**p<.05, **p<.01, ***p<.001*

Model 2: Demographics, Hygiene Factors, & Motivator Factors

Addressing the third research question, (*How do motivator factors improve our understanding of STEM student persistence beyond the model with hygiene factors?*), the results of a second model are presented in this study testing the main effects of demographics and hygiene factors combined with motivator factors, which are intrinsically motivating determinants of worker satisfaction (see Table 4). The variables for motivator factors in Model 2 are represented with proxies of known factors of persistence, which fall under four categories: the work itself/responsibility, opportunity for growth, recognition, and achievement.

Examining the baseline variables of the multinomial logistic regression, there are new developments with the main effects of the demographic variables. Holding all other predictors constant, females become significantly associated with no degree as compared to STEM degree completion with a relative risk of 1.92 ($p<.05$), whereas females were not significantly associated in the prior model. Additionally, female students continue to be significantly associated with earning a non-STEM degree in comparison to a STEM degree with a relative risk increasing by a factor of 2.27 ($p<.001$).

As for race/ethnicity variables, Asian students maintain a significant and negative association with the relative risk of no degree decreasing by a factor of .48 ($p<.05$) and switching to a non-STEM degree outcome decreasing by a factor of .43 ($p<.05$), indicating the likelihood of STEM persistence to degree completion. Significance drops to the .05 level in both outcomes. In this model, black students are no longer significantly associated with no degree as compared to the STEM degree outcome. However, earning a non-STEM degree remains significant, with a lower significance level and relative risk increasing by a factor of 2.33 ($p<.05$). Variables for Hispanics and students of other races remain insignificant for all outcomes.

Observing the main effects of hygiene factors in Model 2, the same variables remain significant, but with three notable changes. Institutional selectivity under the academic environment category loses significance when regressed upon the non-STEM degree outcome;

however, the variable continues to negatively predict a no degree outcome with a relative risk decreasing by a factor of .69 (p<.001), indicating a significant association with STEM persistence. Under the personal life category, the variable indicating students who live with at least one parent loses significance for the no degree outcome vs. STEM degree. Loan amount under the financial assistance category also loses significance.

Among variables that remain significant, faculty interaction outside the classroom continues to decrease the relative risk of switching majors by a factor of .40 but with a lower significance level (p<.05), demonstrating a negative association with switching to a non-STEM degree. Regarding financial assistance, having all or at least half of tuition and fees paid for by grants and scholarships in the first term remains negatively associated with no degree, with a relative risk decreasing by .63 and .59 respectively at lower significance levels than the previous model (p<.05). Moreover, under the personal life category, having at least one parent with a four-year degree decreases the relative risk of no degree by a factor of .39, with a lower significance level of p<.05. All other hygiene factors remain insignificant.

Shifting over to the motivator factors, several of the variables were found to be significant predictors in Model 3. In the work itself/responsibility category, participating in internships and co-ops decreases the relative risk of a no degree outcome by a factor of .76 (p<.001), indicating a significant likelihood of persisting in a STEM major. However, internships and co-ops do not significantly predict a non-STEM degree outcome. In the same category, research with a faculty member outside the classroom does not have a significant relationship with no degree; however, the variable significantly decreases the relative risk of earning a non-STEM degree by a factor of .55 (p<.01), thereby significantly predicting a STEM degree.

Under the category of opportunities for growth, the variable for studying abroad is insignificant for all outcomes. However, the variables for service learning and community-based projects increase the relative risk of a non-STEM degree outcome by a factor of 2.42 ($p<.001$), indicating these activities negatively predict STEM persistence. Moreover, there is no significant association between service learning and no degree as compared to a STEM degree. For the category of recognition, the variable for receiving mentorship does not predict the no degree outcome; however, it does show a negative association with earning a non-STEM degree with a relative risk decreasing by a factor of .49 ($p<.05$), indicating a significant relationship with STEM persistence.

The final category, achievement, is represented by two variables, GPA in the first year of college and total GPA throughout the student's postsecondary experience. The model shows that a one-unit increase in first-year GPA decreases the relative risk of no degree by a factor of .47 and decreases the relative risk of earning a non-STEM degree by .41 ($p<.001$). Total GPA is also significant, with a relative risk of no degree decreasing by a factor of .71 for every one-unit increase in GPA ($p<.001$). However, total GPA has no significant association with switching majors to a non-STEM degree.

To understand the effect of adding motivator factor variables to the model with demographic and hygiene factors, a post-estimation test was conducted on the motivator factor variables to check their significance. The post-estimation test indicates a significant improvement of the model, $F(26, 1302.0) = 5.12$, $p<.001$. With the exception of the positive association of service learning with changing to a non-STEM major, intrinsically motivating activities when added with hygiene factors appear to significantly improve the association with a STEM persistence outcome.

Table 4.4. *Model 2: multinomial regression with demographics, hygiene, and motivator factors*
ELS: 2002 (n=1,319)

	NO DEGREE			NON-STEM DEGREE		
Variable	**RRR**	**SE**	**Sig.**	**RRR**	**SE**	**Sig.**
Sex						
Female	1.92	(0.51)	*	2.27	(0.48)	***
Race/Ethnicity						
Asian	0.52	(0.15)	*	0.57	(0.14)	*
Black	1.58	(0.56)		2.33	(0.80)	*
Hispanic	1.49	(0.61)		1.52	(0.54)	
Other race	1.20	(0.74)		1.37	(0.65)	
Hygiene Factors						
Faculty interaction	0.98	(0.27)		0.60	(0.13)	*
Extracurricular activities	0.82	(0.19)		0.99	(0.19)	
Meeting with advisor	0.69	(0.25)		1.06	(0.38)	
Grants & scholarships	0.93	(0.27)		0.78	(0.20)	
All tuition/fees paid by grants & scholarships in first term	0.37	(0.15)	*	0.66	(0.22)	
At least half of tuition/fees paid by grants/scholarships in first term	0.41	(0.17)	*	0.73	(0.23)	
Less than half of tuition/ fees paid by grants & scholarships in first term	0.69	(0.25)		0.77	(0.22)	
Work-study	0.96	(0.34)		0.83	(0.25)	
Family contribution	0.92	(0.22)		1.12	(0.22)	
Loan amount (scaled to $1000)	1000	(0.01)		1000	(0.00)	
High institutional selectivity	0.31	(0.08)	***	0.70	(0.15)	
Parent with a 4-year degree	0.61	(0.15)	*	1.11	(0.25)	
Lives with parent(s)	1.23	(0.32)		0.98	(0.23)	
Motivator Factors						
Internship/co-op	0.24	(0.06)	***	0.79	(0.16)	
Undergraduate research	0.78	(0.26)		0.45	(0.12)	**
Study abroad	0.44	(0.22)		0.81	(0.26)	
Service learning	1.05	(0.37)		2.42	(0.63)	***
Mentorship	1.28	(0.45)		0.51	(0.14)	*
GPA in first year	0.53	(0.09)	***	0.59	(0.09)	***
Total GPA	0.29	(0.07)	***	1.07	(0.23)	

**p*<.05, ***p*<.01, ****p*<.001

Interaction Effects Between Demographics and Motivator Factors

To understand the final research question (*Do the relationships between motivator factors and STEM student persistence vary significantly across sex and race/ethnicity?*), a final set of regression tests was conducted to understand potential relationships between females and motivator factors found to be significant in Model 3, as well as between race/ethnicity and the same motivator factors. An initial model with the addition of all motivator factors paired with the variable female indicated a significant interaction between female and internships on the STEM persistence outcome with a relative risk of no degree increasing by 3.40 ($p<.05$). All other interaction terms for female and motivator factors were insignificant, indicating that motivators factors besides internships and co-ops do not vary by sex. Moreover, the female*internship interaction term was then added to the model on its own to test if it improves the model combining demographics with hygiene and motivator factors. However, the test revealed that there is no significant interaction effect between female and internships, indicating that the relationship between STEM persistence and motivator factors are the same for both female and male STEM students.

A separate regression model tested interaction effects between motivator factors and race/ethnicity. The test shows a significant decrease in the relative risk by a factor of .99 of earning a non-STEM degree between the interaction of mentorship and students of other races regressed on the STEM persistence outcome ($p<0.05$). No other significant interaction terms were found, indicating that motivator factors other than mentorship do not vary across race/ethnicity. Since mentorship was found to be significant with the *other race* variable, interaction terms for mentorship and each race/ethnicity was added to the model without the other motivator factors. A post-estimation test was then conducted, revealing that the addition of interaction terms between mentorship and race/ethnicity does not significantly improve the model. Therefore, the results of this test indicate that the effect of motivator factors on STEM persistence do not differ across race/ethnicity.

Summary of Results

In summary, this study examined STEM undergraduate persistence in four parts, using a two-factor theory framework. To understand the persistence rate among STEM students by race/ethnicity and sex, a frequency distribution and cross-tabulation were conducted. This result showed that 41% of students who begin in a STEM undergraduate program will complete a STEM degree. Among the 30% of females who declared a STEM major, only 37% completed a STEM degree, while only 43% of the 70% of males who intended on a STEM major graduated with a STEM degree. This percentage difference between men and women was found to be significant in the model testing the main effects of the variable, female, on the STEM persistence outcome. With regard to race and ethnicity, Asians persist in STEM at the highest percentage (54%), followed by white students at 43%. However, only 24% of black students and 30% of Hispanics persisted in their STEM programs. The likelihood that Asians will persist to STEM degree completion was found to be significant in all models, while black students switching to a non-STEM major was significant in the final model with both hygiene and motivator factors.

Multinomial logistic regression was also used to test how hygiene factors may predict the STEM persistence outcome. The final model combining demographics with hygiene and motivator factors showed that faculty interaction is significantly associated with keeping students in STEM majors. Additionally, having at least half to all of tuition and fees paid for by grants and scholarships early in the college experience is significant to STEM degree completion.

Having at least one parent with a college degree and attending a highly selective institution is also associated with persistence to graduation.

The model was further tested by the addition of motivator factors in a second block entry, which is associated with intrinsically motivating activities. Staying in the STEM major was predicted by participating in undergraduate research and receiving mentorship, while the prevention of college dropout was associated with internships and co-ops. Moreover, a one-unit increase in total GPA also decreased the likelihood of college attrition by a factor of .71, while a one-unit increase in GPA in the first year decreased attrition by a factor of .47 and prevented switching to a non-STEM a major by a factor of .41. Curiously, however, service learning and community-based projects were associated with switching majors, which will be discussed in the next chapter. The addition of motivator factors was also tested, which indicated a significant improvement over the model with just demographics and hygiene factors.

Finally, in order to determine if significant motivator factors vary by sex and race/ethnicity, interaction terms were tested separately between female students and the motivator factors, as well as between each race/ethnicity category and the motivator factors. Ultimately, no interaction terms were found to be significant, meaning that motivator factors predict STEM persistence equally across sex and race/ethnicity. In Chapter 5, these results will be discussed further, along with potential implications for policy and directions for future research.

Chapter Five: Conclusion and Implications

Given the dire need for more graduates who can enter the STEM workforce, institutions of higher education and programs that support interventions can do more to increase persistence among students with STEM majors. Several reports point to challenges related to chilly and unsupportive academic environments that become barriers to the academic success of STEM students in college (Chinn, 1999; NASEM, 2016; PCAST, 2012). Previous research and theories have focused heavily on financial access and student engagement to understand STEM persistence (Chang et al., 2014; Espinosa, 2011; Fenske, Porter, & DuBrock, 2000; Whalen & Shelley, 2010; Xu 2016).

Moreover, some research specific to the STEM student experience points to the importance of psychological factors that may influence student persistence. In particular, self-efficacy in STEM educational activities, motivation through explored STEM interests, and recognition by relevant science authorities in students' abilities as science-capable individuals can have significant implications on their motivation to persist (Adumuti-Trache & Andres, 2008; Brainard & Carlin, 1998; Carlone & Johnson, 2007; Chang et al., 2014; Perez et al., 2014; Whalen & Shelley, 2010; Xu, 2016). Furthermore, some research indicates that HIPs may play a motivational and compensatory role in student success through engagement in deep learning, but other studies show that these activities have mixed results (Johnson & Stage, 2018; Kuh, 2008; Whalen & Shelley, 2010). Beyond undergraduate research, HIPs are mostly untested on STEM-specific populations as activities to promote persistence.

Given the full range of determinants that play a role in the success of STEM students, this study explored the predictive value of several STEM persistence factors in the context of two-factor theory (Herzberg et al., 1959) as a means to understand how the success of STEM undergraduate students can be fostered more effectively. Influenced by two-factor theory, the conceptual model for this study accounted for variables that are both extrinsic and intrinsic, as Herzberg's theory attempts to explain workforce persistence through extrinsic and intrinsic motivation factors. Accordingly, STEM student persistence was tested using categories related to two-factor theory, but with the incorporation of postsecondary educational variables for hygiene and motivator variables rather than workplace-related factors.

Therefore, this study examined which factors significantly predicted the persistence of U.S. undergraduate STEM students by testing the utility of the two-factor theoretical framework. I also sought to understand how two-factor theory may explain differences across sex and race/ethnicity. To recap, the following questions were examined through this study:

1. What is the persistence rate among STEM students? Are there any sex and racial differences?
2. How do hygiene factors predict STEM student persistence?
3. How do motivator factors improve our understanding of STEM student persistence beyond the model with hygiene factors?
4. Do the relationships between motivator factors and STEM student persistence vary significantly across sex and race/ethnicity?

This chapter will summarize the findings, discuss their implications for institutions and government policies, and provide recommendations for further research.

Persistence Rate of STEM Students

The persistence rate of those students who indicated interest in a STEM degree upon entering college was 41%, while 30% did not earn a degree and another 29% changed majors to earn a non-STEM degree. These statistics show that persistence among STEM undergraduate students decreased when compared with an NCES study looking at national data between 2003 and 2009. The NCES study showed that 52% of STEM students pursuing bachelor's degrees persisted to degree completion, with 20% leaving without a degree and 28% switching to a non-STEM major (Chen, 2013). While this dissertation did not make a comparison to previous STEM populations, it does demonstrate that the issue of STEM persistence remains problematic.

Moreover, in the demographics of this study, the differences by sex and race/ethnicity are most striking. For example, female students had a higher rate of STEM persistence than men (14% vs. 24% with no degrees) through degree completion (Chen, 2013). In this dissertation study, 25% of women dropped out, whereas 32% of men did not earn any degree. While dropout rates increased for both sexes, men seem to continue to struggle more in this area. However, differences in persistence rates become starker when reviewing changes in major. The NCES study reported that males fared better than their female counterparts by staying in their STEM major, with 26% vs. 32% of women switching to a non-STEM major. In this dissertation study, changing majors to a non-STEM degree became more polarized, as 38% of women switched to a non-STEM major, while 26% of men did the same.

When it comes to degree completion, women in STEM are similar to their female baccalaureate peers when looking at overall national college trends; women graduate at higher rates than men (National Student Clearinghouse, 2018). However, focusing on the intersectionality of sex when changing majors reveals a separate issue that underscores the challenge for women. Previous studies have cited the existence of cultural barriers for women in the educational environment, which may influence academically capable women to consider majors outside of STEM (Allan & Madden, 2006; Chinn, 1999; Hall & Sandler, 1982; Wilson, 2000). This study, however, did not find a significant interaction term for females and the academic environment, which could incorporate only one environmental variable, institutional selectivity. Nor did the study show significant interaction terms between female students and specific motivator factors, such as undergraduate research, internships, and mentorship. Since institutional selectivity and the motivator factors included in this study represent only a limited dimension of the academic environment and potentially intrinsically motivating activities, further research is needed to explore other factors that may deter or promote STEM persistence for women.

With race and ethnicity, the persistence rates among Asian students were highest at 54%, followed by white students at 43%. This study demonstrated that Asian students are also significantly less likely to switch to a non-STEM degree. Furthermore, black students in this study had the lowest STEM persistence rates at 25%, with 52% never completing a degree and another 23% switching to a non-STEM major, which was found to be significant in the final model. Hispanics in this study also had a low persistence rate at 30%, with 41% never completing a degree and another 29% switching majors, though not statistically significant in the regression models. While a test of interaction effects by race and ethnicity show no variation, previous studies have connected the success of Asian and white students to the access of cultural capital from degree-bearing parents who convey the importance of postsecondary education and have the experiential knowledge and resources to support their children (Wells, 2009).

These studies also point to a lack of cultural capital and the failure to cultivate a capable STEM academic self-concept for black and Hispanic students who may not have the same access to educational support as their Asian and white counterparts. This study did not explore the predictive significance of pre-college characteristics, such as early self-efficacy in math and science abilities, as well as access to cultural capital beyond having a parent with a degree.

Exploration of STEM prior to college is a known factor in developing efficacy and interest in STEM later in college (Adumuti-Trache & Andres, 2008; Perez et al., 2014); this may cultivate the cultural capital needed to build confident science identities in underrepresented students. Furthermore, institutional factors may also account for low persistence of black students in STEM majors, as these students may experience cultural barriers in their academic programs (NASEM, 2016; PCAST, 2012). The challenges of STEM cultural barriers might be remedied through engaging instructional methods, peer-led interactions, and active learning techniques, which may help increase persistence for STEM students of color (Dancy & Henderson, 2010). Moreover, further investigation is needed into various forms of cultural capital and the educational environment and their impact on STEM students. Understanding student opportunities to explore STEM prior to college and questions regarding the STEM-related experiences of students of color are necessary to fill in the knowledge gaps regarding the low persistence for URMs.

Significance of Hygiene Factors

Hygiene factors in two-factor theory are thought to be extrinsically motivating determinants of workplace dissatisfaction, potentially leading to low productivity and workplace turnover when not adequately addressed (Herzberg et al., 1959). This study substituted equivalent proxies for workplace hygiene factors with variables of STEM undergraduate persistence, which are grouped into one of five categories: interpersonal relationships, academic advisement, financial assistance, academic environment, and personal life. In general, several variables in these categories significantly predicted a STEM outcome, while others showed no significance. This section will discuss the potential implications of the variables chosen for hygiene factors.

Interpersonal relationships.

For the category of interpersonal relationships, two variables were used to test their correlation with the STEM persistence outcome: participation in extracurricular activities and interaction with faculty outside the classroom. In the tradition of previous studies on persistence and retention testing Tinto's (1975, 1987) theory of social interaction, these variables were used to test how social and academic interaction may predict the persistence outcome for STEM students. Some previous studies on STEM students have shown social interaction with peers did not yield significant results (Whalen & Shelley, 2010; Xu, 2016), while other studies have shown that peer-based interaction through STEM-related extracurricular activities keeps students in their majors (Espinosa, 2011).

This study found that broad participation in extracurricular activities regardless of any connection to a STEM major does not significantly predict STEM persistence. As this variable represented general participation in any extracurricular activity, the finding may indicate that social interaction with peers outside of a student's discipline may play a lesser role in motivating students to persist in STEM majors. This finding, when compared to other studies, is unsurprising when understood through Holland's (1959) theory of vocational choice; students will choose to stay in their major when surrounded by those with similar characteristics to themselves. Due to the academic rigor and specialized nature of STEM, it may be that only peers and activities associated with their major, such as joining a major-related professional association, would help foster persistence (Espinosa, 2011).

In addition to peer interaction, this study also examined the relationships of faculty-student interaction outside the classroom. In previous research, scholars have touted the benefits of faculty-student interaction when it comes to student success (Astin, 1993; Kuh, 2008; Lambert et al., 2012; Pascarella & Terenzini, 2005), yet research specific to STEM students has shown that more interaction is negatively associated with persistence for women and underrepresented minorities who perceive the environment to be unsupportive (Chang et al., 2014; Espinosa, 2011). Moreover, past studies on faculty interaction with students have demonstrated the quality of faculty relationships are tied to the likelihood of STEM student persistence (Kuh, 2008). This study only examines whether a higher level of faculty interaction outside the classroom significantly predicts the STEM persistence outcome. As such, this study found that a moderate to high level of interaction with faculty outside the classroom was significantly associated with keeping students in STEM majors.

This latter finding is curious, given the results of previous studies whereby women, blacks, and Hispanics were likely to switch to a non-STEM major as predicted by increased faculty interaction (Chang et al., 2014; Espinosa, 2011). While the nature of the interactions cannot be determined from this study, it may be that faculty play a role in keeping students in their STEM program through academic interaction. Furthermore, students who persist in their STEM majors may be more motivated to find opportunities to talk to their professors outside of the classroom regardless of race/ethnicity or sex. While this variable was not intended for the category of academic environment, the significance of faculty willing to interact with students outside of the classroom might also suggest that the academic climate is supportive for STEM students who persist in their chosen program and may indicate an improvement in the STEM educational climate.

Academic advisement.

In the category of academic advisement, the variable for receiving advisement was intended to test how guidance and supervision from a professional or faculty advisor in a student's major may support STEM persistence. The results of this study show no significance of academic advisement on the STEM persistence outcome. I chose academic advisement as a parallel to the original hygiene factor of supervision due to similar experiences of individuals who may feel undifferentiated from others. Previous research has shown that the quality of advisement for STEM majors may be poor, particularly among faculty advisors who have competing priorities to do research and teach, as well as professional advisors who must meet with numerous students (McCuen et al., 2009; Vowell & Farren, 2003). Therefore, the limited attention to students from advisors may not be associated with STEM persistence, but neither does academic advisement negatively predict persistence. It could be that students who persist in STEM majors are already well-informed about their programs and therefore do not need as much time with their advisors. More research is needed to understand how the perceived experiences of STEM student advisement may impact student success.

Financial assistance.

I chose several variables for the category of financial assistance. Corresponding to the hygiene factor of salary, financial assistance is assumed to be necessary for STEM students to persist to degree completion, while insufficient financial means would predict failure to complete a STEM degree. Supporting this notion, two variables proved to be significant in the final model for preventing dropout: (a) having at least half of tuition and fees paid for by grants and scholarships in the first academic term and (b) having all of tuition and fees paid for by grants and scholarships in the first term. This result seems to conflict with past research showing that STEM students who receive Pell grants were significantly more likely to drop out of college than non-STEM majors (Chen, 2013). Since Pell grants are provided based on the expected family contribution, this phenomenon may be connected to other studies showing a significant association of high financial need with low persistence among STEM students (Whalen & Shelley, 2010).

However, for this study, the proportion of tuition and fees that can be covered includes multiple sources of grants and scholarships, and consequently, the negative association of anticipated financial need may be offset by the addition of scholarships and merit-based grants that are awarded for strong grades prior to entering college, an indication of high academic ability. Thus, receiving grants and scholarships (some of which are based on academic merit) that cover at least half of tuition and fees in the first term may help explain STEM persistence, as previous research has shown that a high pre-college GPA strongly predicts persistence (Astin, 1997; Hoffman & Lowitzi, 2005; Livingston, 2007; Munro, 1981; Stewart, Lim, & Kim, 2015; Zheng, Saunders, Shelley, & Whalen, 2002).

The significance of these variables is further underscored when compared to another categorical variable in the study, receiving financial aid through grants and scholarships as of the F2 survey (second year of college), which was not significant. In comparing these variables, early access to grants and scholarships may be an indication of academic ability in addition to playing a significant role in helping STEM students to succeed in college. However, the insignificance of receiving grants and scholarships without regard to the proportion that is paid toward tuition may support the idea of financial aid as a hygiene factor. The ability to sufficiently pay for tuition is crucial for STEM students to advance through their program, and therefore, participation in intrinsically motivating activities may not compensate for financial instability.

Moreover, the variables loan amount and family contribution were both found to negatively predict a no degree outcome in the first block-entry model. The significance of loans in Block 1 parallels some previous studies on college students in which loans were associated with persistence (Astin, 1975; Chen, 2008; Chen & DesJardins, 2008; Voorhees, 1985), and at least one study on STEM students demonstrates a similar finding (Whalen & Shelley, 2010). To some degree, loan amount may be associated with institutional persistence, as those who advance through each year of their curriculum will likely accrue more debt. Previous research has also found the importance of family contribution in supporting persistence (Olbrecht, Romano, & Teigen, 2016). However, both variables in this study lost significance in the second model when controlled for by motivator factors. Therefore, the loss of significance for these variables does not provide additional support to the notion of all forms of financial aid as hygiene factors, which would, in theory, play a basic role in maintaining persistence as an extrinsic motivator, particularly as motivator factors come into play in the STEM persistence experience.

The final variable to be discussed under financial assistance is work-study. Work-study showed no significance for STEM persistence in either model tested, only adding to the inconsistency results of previous research. Pascarella and Terenzini (2005) found work-study to be significant, concluding that it may support persistence by connecting students to the on-campus environment. Likewise, in one of the few studies examining work-study as a predictor of STEM student persistence, Whalen and Shelley (2010) found a substantial increase in retention for every $1,000 earned in a study examining the effect of financial aid at one institution. In contrast, St. John and Starkey (1995) found that work-study decreases persistence for lower-middle-income students. Moreover, Soliz and Long (2016) found that work-study increased credit accumulation, while Scott-Clayton and Minaya (2016) found that work-study increased the likelihood of a bachelor's degree in six years by three percent. Although work-study may help students to persist financially, its benefit may be negated by the time required for work, taking away from valuable time that could be spent on rigorous STEM academic work. Given limited previous research and the insignificant results of this study, the predictive power of work-study remains uncertain for STEM students.

Academic environment.

Academic environment was included in this study to replace the original hygiene factor category of workplace conditions. Much of the literature on STEM persistence has focused on the academic climate, often described as "chilly" toward women and URMs and characterized by an unsupportive culture among faculty and educational environments that are incongruent with the experiences of diverse students (Allan & Madden, 2006; Hall & Sandler, 1982; NASEM, 2016; PCAST, 2012). To represent the academic environment, the variable included in this category was high institutional selectivity. Previous studies have shown enrollment in highly selective institutions to have positive associations with college persistence, particularly for women and URMs (Alon & Tienda, 2005; Bowen & Bok, 1998; Trent et al., 2003), yet several other studies have found the reverse for URMs and women of color in STEM programs (Astin & Astin, 1992; Bonous-Hammarth, 2000, 2006; Chang et al., 2008; Espinosa, 2011; Elliott et al., 1996). In contrast, an NCES report in 2013 found that STEM students in general who attended the least selective institutions were more likely to leave college without a degree (Chen, 2013).

The result of this dissertation study provides additional support for the significance of selectivity, finding that STEM students who attend highly selective institutions were more likely to stay in college and persist to STEM degree completion. It should be noted that several of the studies examining the persistence of URMs in STEM programs only tested outcomes based on changing majors to a non-STEM major, thereby leaving out the outcome of those who did not complete a degree. This study broadens the scope of STEM persistence to both those who did not complete a degree and those who changed to a non-STEM major, which may affect institutional selectivity as a predictor.

In the first model, including only demographics and hygiene factors, high selectivity was found to be negatively and significantly associated with both the no degree and non-STEM degree outcomes. However, only significance for the no degree outcome remained with the addition of motivator factors. Therefore, attending a highly selective institution predicts a STEM persistence outcome by way of staying in college when controlling for motivator factors. This may be explained by the strong academic abilities and high motivation of students who are enrolled at highly selective institutions. However, environmental influences cannot be ruled out, as previous studies have also pointed to the investment in supportive resources found at highly selective institutions that may enhance persistence in students (Alon & Tienda, 2005; Bowen & Bok, 1998; Trent et al., 2003).

Personal life.

The final category to be discussed among hygiene factors is personal life. This category was included to test how factors of a student's personal life may be associated with the persistence outcome. This study included two variables formed from the ELS:2002 dataset: living with parents and having at least one parent with a bachelor's degree. Living with parents was found to be significantly associated with a no degree outcome in the first block-entry model. This result is consistent with some previous research, whereby students who commute from home due to challenges with finances, family expectations, and college readiness are more likely to experience low performance and persistence outcomes (Turley, 2006). However, living with parents became insignificant with the inclusion of motivator factors in the second block-entry model. This result may indicate that negative associations with living at home become minimized when STEM students participate in intrinsically motivating activities as well as high-impact practices that stimulate deep learning through engagement (Kuh et al., 2008).

The second variable of the personal life category, having one or both parents with a bachelor's degree, was found to be significant in both block-entry models, with a negative association with the no degree outcome. This variable was included in the model, as it represents a student's access to parental cultural and social capital. Having access to these forms of capital provides an economic and symbolic advantage to those who benefit from parents who have college experience and associate with other degree-bearing families, thereby providing guidance and expectations to students toward degree completion (Bourdieu & Passeron, 1977; Perna, 2000; Wells, 2009). In contrast, students with low cultural and social capital may self-select out of educational opportunities, lower their educational aspirations, and receive fewer rewards and benefits for their effort (Bourdieu & Passeron, 1977; Lamont & Lareau, 1988; Wells, 2009). Therefore, this study lends support to the notion that STEM students may also benefit from the cultural and social capital that comes from college-educated parents.

Significance of Motivator Factors

In two-factor theory, motivator factors represent a separate track of influences from hygiene factors. Motivator factors are intrinsically motivating determinants of workplace satisfaction, which are thought to increase productivity and allow employees to thrive (Herzberg et al., 1959). As with the hygiene factors, this study substituted equivalent proxies for workplace motivator factors with variables of STEM undergraduate persistence, categorized into the following: the work itself/responsibility, opportunity for growth, recognition, and achievement. These variables were added in a second block-entry to the initial model that incorporated demographic and hygiene factor variables. Several variables in these categories significantly predicted a STEM outcome, improving the model in a post-estimation test. This section will discuss the potential implications of the variables chosen for motivator factors.

The work itself and responsibility.

The first two categories of motivator factors in this study are combined as the work itself and responsibility. In two-factor theory, the work itself represents the satisfaction gained from performing duties relevant to the work, while responsibility relates to the satisfaction achieved in the challenge and importance of the work (Herzberg et al., 1959). This study used two variables to represent these categories: participation in research outside the classroom and participation in an internship or co-op. Research outside the classroom was found to be significantly associated with STEM persistence, with a decreased likelihood of switching to a non-STEM major. This result supports previous research findings in which undergraduate research significantly predicts STEM persistence (Chang et al., 2014; Espinosa, 2011; Xu, 2016).

Moreover, participation in internships and co-ops was also significant, but with a decreased likelihood of a no degree outcome. As discussed in Chapter 3, a 2012 report from NACE showed that 40% of its survey respondents chose to participate in internships and co-ops early in their college experience. Subsequently, there may be other reasons for the significance of these variables on the persistence outcome beyond when students chose to participate.

Assuming that the significance of undergraduate research and internships/co-ops to STEM persistence is not just a matter of timing, several scholars have lent support to the intrinsically motivating impact of such activities on STEM persistence. For example, Espinosa (2011) stated that research program involvement, which facilitates positive interactions in science environments, might boost the confidence of women in STEM. Carlone and Johnson (2007) and Lane (2016) specified that the practical-application STEM and intentional programmatic efforts to foster science identities provide opportunities to perform science and demonstrate competence, playing a significant motivational role in persistence. Chang, Sharkness, Newman, and Hurtado (2014) concluded that students who participate in applied and hands-on STEM activities feel more personally connected to their STEM program, thereby helping them persist. Given the conclusions of these researchers, it is a fair assumption that the results of this study lend further support to undergraduate research and internships/co-ops playing a significant role in the promotion of STEM persistence as intrinsically motivating practices.

Opportunity for growth.

The category of opportunity for growth is included in this study to include factors that may help students develop themselves and grow as individuals. In the original two-factor theory study, this category encompassed training, certifications, and professional development opportunities for employees. In this study, the variables chosen to fit this category were participation in service learning/community projects and study abroad. As high-impact practices, service learning and community projects have been linked to a number of positive student success outcomes, such as development of academic efficacy, elevated course grades, and civic responsibility (Astin & Sax, 1998; Batchelder & Root, 1994; Celio, Durlak, & Dymnicki, 2011; Markus, Howard, & King, 1993). However, only a few studies have found a positive association between service learning and persistence. Bringer, Hatcher, and Muthiah (2010) found that participation in a fall-term service-learning course increased intentions to persist to the next fall term, while Lockeman and Pelco (2013) found that service-learning students were more likely to earn more credits, earn a higher GPA, and graduate over their non-service learning counterparts. In STEM-specific studies, research on the positive outcomes of service learning are rare; one study by Hayford, Blomstrom, and DeBoer (2014) showed outcomes of earning higher grades and increased STEM literacy, but there is little information on the association with persistence.

This study provides much-needed knowledge, demonstrating that participation in service learning increased the likelihood of a non-STEM degree. One reason for this finding may be that non-STEM disciplines tend to support service learning more than STEM disciplines. While there seems to be no existing inventory of service-learning programs by major and discipline, a federal program under the Corporation for National and Community Service named Learn and Serve America (2010) supported the use of service learning in STEM as a growing but innovative approach to foster STEM interest and persistence. The program's recommendation suggests that service learning is not a common practice in science and technology disciplines. Moreover, one study examined the possibility and took inventory of service learning as a program major or minor at postsecondary institutions. Most of these majors and minors were housed in programs related to non-STEM disciplines such as public service, civic and community engagement, social justice, and leadership studies (Butin, 2010). Assuming that service learning is not the norm in STEM disciplines, it is not surprising, then, that it may be associated with switching to a non-STEM major if student interests lie in finding fulfillment through service-learning work.

The second variable for the opportunities for growth category was participation in study abroad. This variable was included under this category because some studies have connected study abroad to positive student development outcomes, such as intercultural understanding and global engagement (Paige, Fry, Stallman, Josic, & Jon, 2009; Stebleton, Soria, & Cherney, 2013; Vande Berg, Connor-Linton, & Paige, 2009). Furthermore, some institutional and state education system studies have shown that students who study abroad are more likely to complete a degree than students who do not participate in study abroad, including students in engineering majors at one institution (Hamir, 2011; Malmgren & Galvin, 2008; Redden, 2012; Sutton & Rubin, 2010; University of California, San Diego, 2009). In this study, no statistical significance was found between study abroad and the STEM persistence outcome. Given that study abroad is connected to other student success outcomes such as global engagement and cultural competence (Fry, Stallman, Josic, & Jon, 2009; Stebleton, Soria, & Cherney, 2013; Vande Berg, Connor-Linton, Paige, 2009), it may be that the motivation to participate does not necessarily tie directly to a student's interest in STEM or the student's disciplinary curriculum. Therefore, while not detrimental to persistence, study abroad may not play a substantial role in advancing students along in their STEM program as an opportunity for growth.

Recognition.

The next motivator factor from two-factor theory is recognition. This factor was a central theme among workers in the original two-factor theory research who felt a sense of satisfaction from the recognition of value received from their supervisors and fellow employees (Herzberg et al., 1959). These workers' narratives parallel the bolstering of affirmed science identities as researched by Carlone and Johnson (2007); the science identities of STEM students were reinforced when significant science authorities, such as professors, recognized them as competent and knowledgeable beyond just faculty-student interaction (Carlone & Johnson, 2007). To test this category, the receiving of mentorship was included in the model as a variable representing a meaningful form of recognition, which was found to be significant for keeping STEM students in their majors.

Similarly, several studies have found that mentoring is an effective means to support persistence in undergraduate students, especially for URMs (Campbell & Campbell, 1997; DuBois et al., 2002; Freeman, 1999; Good et al., 2000; Redmond, 1990). The efficacy of specific programs designed to help students through faculty and peer mentorship has also been established in STEM support programs, such as the Howard Hughes Medical Institute Professors Program at Louisiana State University (Wilson, Holmes, deGravelles, Batiste, Johnson, McGuire, Pang, & Warner, 2011). This study lends further support to the notion that recognition of STEM students' abilities through mentorship can play a crucial role in reaffirming competence and efficacy, thereby helping them to persist within their STEM major program.

Achievement.

The final category of motivator factors used in this study is achievement. In two-factor theory, this category represents the satisfaction that an employee may feel from a sense of accomplishment (Herzberg et al., 1959). In converting this category for STEM persistence, two continuous variables were chosen to represent measurable forms of achievement: GPA in the first year and total GPA. First-year GPA was found to decrease the risk of no degree by a factor of .47 for every unit increase, as well as decrease the risk of changing to non-STEM major by a factor of .41 for every unit increase. Previous research has found the significance of first-year academic performance among college students in general to significantly predict persistence and degree attainment (Allen & Robbins, 2010; Westrick, Le, Robbins, & Radunzel, 2015). This study finds that this is also significant for STEM students specifically. While a high first-year GPA may be an indication of strong academic ability, it may also support the notion that early academic success is a strong motivator in bolstering self-efficacy and feelings of competence that help students to advance through their STEM program.

The variable of total GPA unsurprisingly predicts a decrease in a no degree outcome by a factor of .71 for every unit increase in GPA. High cumulative GPA is a known factor in predicting STEM persistence through degree completion (Chen, 2013; Whalen & Shelley, 2010;

Xu, 2015). However, NCES has found a significant association with changing majors to non-STEM majors in students who achieve a 3.5 or higher (Chen, 2013). Some scholars have concluded that higher-performing students may leave STEM majors for fields that offer higher earnings, such as business or health care (Bettinger, 2010; Shaw & Barbuti, 2010). This study found no significance in total GPA when controlling for motivator factors. Perhaps the addition of intrinsically motivating activities, such as research and internships, may help to cancel out the effect of earning a higher GPA on switching majors; however, that notion remains inconclusive with the current study. Future research can study which majors STEM students who switch to a non-STEM discipline are more likely to pursue and examine the reasons for changing their major.

Finally, a post-estimation test was conducted on this study to determine if the addition of motivator factors to hygiene factors and demographics significantly improved the model. The results indicated that it does improve the model. While this does not prove the validity of two-factor theory as having separate tracks of factors related to satisfaction and dissatisfaction, it does indicate that the addition of potentially intrinsically motivating activities has greater utility in predicting STEM persistence than hygiene factors alone. This result lends support to the idea that HIPs are positively associated with student success and can compensate for lower cultural capital or other ways in which students may be disadvantaged (Kuh et al., 2008). Moreover, it also points to psychological factors as an essential determinant of STEM persistence, as motivator factors such as internships, research, mentorships, and early academic successes are opportunities to foster confidence and competence in STEM-related activities (Lane, 2016; Whalen & Shelley, 2010; Xu, 2015).

Interaction Terms

This study also sought to understand differential relationships across race/ethnicity categories and female students with motivator factors and the STEM persistence outcome. Ultimately, no significant interaction terms were found for any relationships between STEM persistence and motivator factors. The lack of variation in interaction terms indicates that the relationship between motivator factors and a STEM persistence outcome is the same for all race/ethnicity and sex categories. This result differs from the research of Kuh et al. (2008), in which HIPs were found to be compensatory for underrepresented students. However, the main effects of motivator factors in this study show that participation in intrinsically motivating activities predicts persistence for all STEM students and therefore has an equal benefit for women and students of color.

Implications for Policy

There are several implications of this study as government and postsecondary institutions seek to help STEM students to persist and fill vacant opportunities in the workforce. This study focused on how factors related to extrinsic and intrinsic motivation predict persistence for STEM undergraduates as conceptualized by two-factor theory. Findings for this study may help postsecondary institutions to augment their STEM academic programs, better target their efforts toward educational support services and practices that benefit STEM student persistence, as well as encourage programmatic and financial support by government programs through interventions and policies that stimulate STEM engagement and motivation. Moreover, this study reveals that while some extrinsically motivating factors remain significant as predictors of STEM persistence, the development of intrinsic motivation in STEM students may play a pivotal role in the STEM persistence problem.

A significant focus of this study, the issue of STEM persistence may be due to a cultural mismatch between students of diverse backgrounds and their academic environment (NASEM, 2016; PCAST 2012; Reimer, 2017). This mismatch might be indicated by the low persistence of all students who pursue STEM majors, but especially female, black, and Hispanic students. Moreover, the benefit of a diverse STEM workforce may be overlooked; for example, Dezsó and Ross (2007) found that a diverse mix of men and women at the managerial level was associated with a $42 million value increase of S&P 500 companies over male-dominated firms, and there was a 40% difference increase in IT patents filed by mixed-gender teams over male-only teams (Ashcraft & Breitzman, 2012).

Given the negative persistence levels of women and black students especially, institutions must assess the cultural climate of their STEM academic programs to ensure that women and students of color feel supported and implement intentional interventions to make change. The success of programs that focus on support for underrepresented students is seen in specific institutional-based programs (Lane, 2016; Wilson, Sylvain, & McGuire, 2011), but colleges and universities have yet to implement the cultivation of cultural capital to all underrepresented students universally. While not every student has the benefit of having parents who obtained a four-year degree, colleges and universities can provide more support to parents and their students by sharing expectations and helping build a shared sense of cultural capital.

I am careful here to not suggest that students should attempt to mold themselves entirely to the college environment. Colleges and universities must be open to the diverse cultures of their students and adapt their environments to inspire their students. However, it may help students to understand the expectations of their STEM major program and have a dialogue with faculty members and administrators to establish a rapport. Some secondary schools have employed the intentional use of cultural capital translators to help college-bound students make sense of their options and educational expectations (Rosenbaum & Naffziger, 2011). Perhaps this strategy can be used at the postsecondary level through orientation programs, first-year seminars, and other programs focusing specifically on the experience of first-generation and underrepresented college students.

While focusing on the cultural and environmental aspects of the institution is significant, paying for college remains a crucial means of STEM persistence. Despite the focus on motivator factors, one of the most pertinent hygiene factors, as illustrated in this study, is the ability to pay for tuition and fees, especially early in a STEM student's college career. Of concern to many college-going students in recent years is the decrease in state grants and the weakening of Pell grants by inflated tuition prices (Goldrick-Rab et al., 2016). This phenomenon may force students to find alternate means to pay for college that may cause burdensome debt or take time away from their rigorous STEM studies because of work obligations, especially if loans and work-study may not have significance in persistence. The federal and state governments must reinvest in financial-aid grants and scholarships to ensure a steady pipeline of graduates to the STEM workforce. Postsecondary institutions and families of college students will likely need to pressure their state and federal government representatives by advocating for financial aid as an investment in the STEM workforce and economic strength for the United States and their regional areas.

Most importantly, colleges and universities would do well to foster the intrinsic motivation of STEM students early in their major. This study lends credence to the idea that the STEM persistence problem is in part a psychological one. However, rather than expecting students to change themselves to fit their educational environment, postsecondary institutions may achieve more success in energizing interest in STEM through structured programs where students feel supported. This study finds that traditional interventions to support students, such as academic advisement, do not play a significant role in STEM persistence, as previous research concludes that students do not feel supported by them (Corts et al., 2000; Keup & Stolzberg, 2004; NASEM, 2016; PCAST, 2012). Those students who have some level of interaction with faculty outside the classroom, or better yet, receive mentorship, experience benefits leading to persistence. I infer from these results that the standard ways of supporting students make them feel undifferentiated from others, but those who are fortunate enough to establish meaningful relationships with STEM faculty and supportive administrators may reap advantages supporting their success.

Accordingly, the results of this study provide support for some forms of motivator factors toward persistence, but participation in HIPs may vary for STEM students. This is evident from the results of the final model, as not all activities purported to promote deep and engaged learning, as in the case of study abroad, may be relevant to STEM persistence. Some HIPs may be associated with switching to a non-STEM major, as with service learning. That is not to say that these types of activities cannot lead to persistence, but rather, that postsecondary institutions should implement intentional opportunities to stoke the intrinsic motivation of STEM students toward their career interests. That could mean creating intentional opportunities within existing programs, as with study abroad, service learning, or other kinds of HIPs, that more directly connect to a student's STEM interests.

Moreover, Carlone and Johnson's (2007) notion of science identity can play a role in recognizing students as competent through intentional structured programs. The significance of undergraduate research and internships/co-ops provides avenues for institutions to generate intrinsic motivation in students and recognize them as science-competent individuals. Rather than making such programs optional, perhaps it would be useful to require students to become more involved in these types of activities as part of their major programs. Requiring these activities may help increase student competence and confidence in their STEM abilities early in college. Moreover, activities that are intrinsically motivating to students are opportunities for STEM students to receive mentorship, which may further reinforce their science identities (Carlone & Johnson, 2007; Lane, 2016). It may be that faculty at colleges and universities traditionally expect such relationships to occur organically, but institutional programs that provide structured mentorship to STEM students have shown promising results (Lane, 2016; Wilson, Sylvain, & McGuire, 2011).

Further Research

While two-factor theory may have some practical application for promoting STEM persistence, there is still much to understand regarding this issue. The notion of hygiene and motivator factors in two-factor theory requires an understanding of the attitudinal facets of the individual experience, particularly as it relates to satisfaction and dissatisfaction. While ELS:2002 data has information on some psychological attributes of STEM students from their secondary school experience, there is insufficient information regarding student attitudes during the college experience. New research can focus on how participation in specific activities, such as research, internships, and co-ops affect the motivation of STEM students. This information may be useful in harnessing the potential of STEM students through intrinsic motivation and infuse potentially beneficial elements into other existing programs or help develop new ones.

Moreover, satisfaction is not the only psychological area that can be researched. More information is needed to understand attitudinal factors related to the academic environment. The effect of institutional selectivity and supportiveness of the academic climate is an area of much-needed exploration. This study found that the main effect of high selectivity is associated with STEM persistence, yet other studies have found the reverse for marginalized cross-sections of the STEM student population, such as women of color (Chang et al., 2011; Espinosa, 2011). The educational environment needs to be parsed out to understand which aspects of an academic setting are either helpful or unsupportive to student success, as well as any potential variations of these effects by demographic groups.

In addition, more information is needed to understand how HIPs may impact STEM student success. While specific institutions may collect this information from their students, surprisingly minimal information is collected on the national level about when students take part in activities such as internships/co-ops, undergraduate research, service learning, and study abroad. As with the academic climate, researchers can explore how these practices impact student persistence goals and delve deeper into the motivational qualities of these activities.

Further research can also be conducted on the psychological effect of achievement and the attitudinal attributes associated with achievement. While this study found a significant association with first-year GPA and total GPA on the persistence outcome, it could not differentiate whether the association is related to academic ability or whether there are also bolstered feelings of self-efficacy from achieving high marks. Moreover, some research has explored the effect of confidence, interests, and perceived costs on STEM persistence (Perez et al., 2014), yet other needed areas of exploration for STEM persistence and achievement may be related to psychological qualities such as grit and growth mindset (Duckworth, Peterson, Matthews, & Kelly, 2007; Dweck, 2008). Grit, as posited by Duckworth et al. (2007), is the combination of perseverance and passion that can help achievement, while Dweck has explored the notion of growth mindset, whereby individuals believe achievement can be developed through effort and persistence. Researching these psychological characteristics and how they relate to STEM students may help create more effective interventions to break through persistence barriers.

Finally, I set out to explore the utility of two-factor theory to examine the STEM persistence problem. While this study demonstrates its usefulness for understanding STEM students, it also reveals some limitations. As with other retention, persistence, and student success models before this study, theoretical constructs must be reformed and improved with the furthering of knowledge. One area for improvement is the incorporation of pre-college characteristics into two-factor theory to understand how these factors may affect the STEM persistence outcome and to control for other factors experienced during college. What students bring into college may affect what they experience during college. Therefore, the STEM persistence model may be improved with the incorporation of pre-college academic factors, such as high school GPA (Espinosa, 2011), experiential factors such as prior exploration of STEM interests (Perez et al., 2014), and attitudinal factors, such as perceived confidence in STEM-related abilities in secondary school (Aryee, 2017). The inclusion of these variables in two-factor theory research may add a deeper level of understanding to STEM student persistence. Ultimately, I hope this research motivates governmental and educational institutions to move beyond the dated routine of STEM education and transform the college experience into one that invigorates the passion of students who wish to successfully pursue their STEM career endeavors.

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Appendix

Correlation Matrix of Variables

	Degree Outcome	Female	Asian	Black	Hispanic	Multiracial	Parent Degree
Degree Outcome	1						
Female	0.0076	1					
Asian	0.1648	0.0584	1				
Black	-0.1742	0.0001	-0.1917	1			
Hispanic	-0.0499	-0.0383	-0.1459	-0.1606	1		
Multiracial	-0.0334	-0.0496	-0.1725	-0.1899	0.8457	1	
ParentDegree	0.2009	0.0975	-0.0161	-0.1058	-0.1122	-0.1001	1
Live with Parents	-0.2659	-0.0714	0.0512	0.0483	0.1466	0.1422	-0.2082
HighSelect	0.3559	-0.0019	0.1184	-0.1693	-0.0675	-0.0526	0.2846
FacultyOften	0.1509	0.0931	-0.0467	0.0558	-0.0408	0.0053	0.0516
Extracurric	0.0125	-0.0055	-0.0291	-0.003	0.0347	0.0219	0.0417
Advisor	0.1368	0.0618	0.0443	0.0278	-0.088	-0.1253	0.0387
Grants/Scholarships	0.0353	0.038	0.0432	0.138	0.0072	0.0061	-0.0789
WorkStudy	0.0029	0.0537	0.0968	0.028	-0.0456	-0.0145	-0.0232
Family Contribution	0.1517	0.0738	0.0159	-0.1605	-0.0263	-0.016	0.2482
Tuition - all	0.049	0.0745	0.0434	0.0886	-0.0742	-0.0414	-0.0984
Tuition - half	0.06	-0.0138	0.0309	0.039	0.1026	0.0728	-0.0033
Tuition - less	0.045	0.0316	-0.0129	0.0032	-0.0743	-0.0746	0.0534
LoanAmount	0.1356	0.0351	0.0798	-0.0319	0	-0.0265	0.0484
Internship	0.3397	0.1269	0.0134	-0.0621	-0.0303	-0.0351	0.1615
Research	0.2581	0.108	0.0607	-0.0919	-0.0183	-0.0175	0.1914
StudyAbroad	0.1763	0.0836	-0.037	-0.0608	-0.0119	0.0035	0.1183
Service Learning	0.1017	0.0975	0.035	-0.0257	-0.0752	-0.0277	0.0913
Mentorship	0.0894	0.1231	-0.0015	0.0344	-0.0468	-0.0656	0.0482
Year1GPA	0.3833	0.0733	0.1581	-0.1975	-0.0432	-0.0481	0.1244
TotalGPA	0.4596	0.1454	0.1371	-0.2878	-0.0581	-0.054	0.2094

	Live with Parents	High Selectivity	Faculty Interaction	Extra-curricular	Advisor	Grants/ Scholarships	Work Study
Live with Parents	1						
HighSelect	-0.3025	1					
FacultyOften	-0.1333	0.0912	1				
Extracurric	-0.0064	0.0546	-0.0615	1			

Advisor	-0.1568	0.1677	0.212	0.1125	1		
Grants/Scholarships	-0.0042	0.0468	0.0655	0.0739	0.0826	1	
WorkStudy	-0.0764	0.1054	0.1152	0.0225	0.1043	0.1894	1
Family Contribution	-0.0864	0.1545	0.0353	0.059	0.0882	-0.1284	-0.0131
Tuition - all	0.0469	-0.0492	0.021	-0.0152	0.0392	0.2882	-0.0127
Tuition - half	-0.0604	0.0723	0.0753	0.0753	0.0703	0.2765	0.252
Tuition - less	-0.0719	0.0539	0.0501	0.0076	0.086	0.1738	-0.0096
LoanAmount	-0.1017	0.0873	0.0253	0.0338	0.0887	0.0894	0.075
Internship	-0.2038	0.208	0.1479	0.0303	0.1457	0.0558	0.0637
Research	-0.2101	0.2683	0.1645	0.0552	0.1231	0.0554	-0.0101
StudyAbroad	-0.1413	0.1975	0.0232	-0.0727	0.0521	-0.0553	-0.0424
Service Learning	-0.1449	0.0837	0.1163	-0.0141	0.0556	0.0403	0.0843
Mentorship	-0.0926	0.0623	0.1283	0.0413	0.082	0.0403	0.0006
Year1GPA	-0.2076	0.1918	0.13	-0.0404	0.0758	0.1216	0.0092
TotalGPA	-0.2266	0.2559	0.1025	0.0003	0.0514	0.0114	-0.0105

	Family Contribution	**Tuition - all**	**Tuition - half**	**Tuition - less**	**Loan Amount**	**Internships**	**Research**
Family Contribution	1						
Tuition - all	-0.2166	1					
Tuition - half	-0.0159	-0.2252	1				
Tuition - less	0.1309	-0.2797	-0.2511	1			
LoanAmount	0.0115	-0.0902	0.0744	0.0889	1		
Internship	0.1299	-0.0118	0.0227	0.1067	0.1165	1	
Research	0.0979	-0.004	0.067	0.0137	0.1942	0.233	1
StudyAbroad	0.0916	-0.0189	0.0286	-0.023	0.0281	0.1447	0.1672
Service Learning	0.0051	0.0259	0.0337	0.023	0.1197	0.2165	0.3135
Mentorship	0.0373	-0.0291	0.0428	0.056	0.1036	0.3397	0.3394
Year1GPA	0.1387	0.0431	0.0959	0.0627	0.1876	0.2176	0.2297
TotalGPA	0.1687	-0.0159	0.0685	0.0116	0.2092	0.3011	0.2892

	Study Abroad	**Service Learning**	**Mentorship**	**Year1GPA**	**TotalGPA**
StudyAbroad	1				
Service Learning	0.1553	1			
Mentorship	0.0891	0.2855	1		
Year1GPA	0.1555	0.068	0.1361	1	