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AP STEM Course-taking and College STEM Major Selection: An Examination of the Relationship and How It Differs by Gender and Race/Ethnicity

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AP STEM COURSE-TAKING AND COLLEGE STEM MAJOR SELECTION: AN EXAMINATION OF THE RELATIONSHIP AND HOW IT DIFFERS BY GENDER AND RACE/ETHNICITY

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Dedication

To my grandmother and dear friend, Rose Schepis. There was no one prouder than she that I earned my PhD.

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Abstract

The United States must expand the STEM pipeline in order to meet the growing demand of the STEM workforce and maintain our nation's prosperity and competitiveness in the global economy. The urgency of this need has been proclaimed by policymakers, business leaders, politicians, and educators. Despite the growing demand for STEM professionals, women and minorities are an underutilized source of intellectual capital that can and should be tapped into to meet the demand. Doing so creates equity across genders and racial/ethnic groups as well as fosters inclusion of more diverse perspectives to enhance STEM innovations. Efforts to expand the number and diversity of those in STEM fields need to start early on in students' academic careers. The purpose of this study was to examine the relationship between Advanced Placement (AP) STEM course-taking in high school and selection of college STEM major and to determine whether the relationship differs across racial/ethnic groups and male and female students. This study was designed to help educators and policymakers shape college preparation programs and policies as well as to counsel students during their course selection process in high school.

A two-level logistic regression model with fixed effects was utilized to determine the relationship between AP STEM course-taking and STEM major selection, controlling for all relevant student-level and school-level variables. Missing data was accounted for through multiple imputations. Sensitivity testing was also conducted to examine whether exposure to AP STEM courses versus number of AP STEM courses matters in the model explaining STEM major selection. Lastly, the analysis also included a series of interaction effects tests, examining the variation of gender and racial/ethnic differences in STEM major selection as a function of AP STEM course-taking.

The sample for this study is taken from the High School Longitudinal Study of 2009 and includes students who were high school freshmen in fall 2009. Data was collected on these students during fall of their freshman year of high school in 2009, during the spring of 11th grade in 2012, and in the spring of 2016, three years after the majority graduated from high school.

Findings indicate that gender, STEM course credits, AP STEM course exposure, math self-efficacy, science self-efficacy, aspiring to a graduate degree or higher, and math SAT score are all significant predictors of STEM major selection. Additionally, the results of the interaction effects test using logistic regression show that the relationship between AP STEM course-taking and STEM major selection varies significantly by gender. More specifically, exposure to AP STEM courses increases the odds of female students selecting a STEM major more significantly than for male students.

Key Words: STEM major, AP STEM courses, HSLS, STEM fields, fixed effects

Chapter I: Introduction

Problem Statement

Policymakers, business leaders, politicians and educators have highlighted the contributions of innovations in science, technology, engineering, and mathematics (STEM) fields to our nation's prosperity and competitiveness in the global marketplace. According to a report by the National Science Foundation (NSF), nearly 50% of our nation's economic growth in the second half of the 20th century was the result of scientific innovation (NSF, 2005). The science and engineering workforce has experienced much more rapid growth over the last several decades than the rest of the workforce, increasing from 1.1 million in 1960 to nearly 6.7 million in 2015 – a 50% higher growth rate than for the total workforce during the same timeframe (NSF, 2018). Bureau of Labor Statistics projections indicate that total employment in science and engineering fields during the period 2014–2024 will increase at a rate of 11% compared to 7% for the total workforce (NSF, 2018).

The President's Council of Advisors on Science and Technology (2012) projects that, in order to meet the growing demand of the STEM workforce and to remain competitive in the fields of science and technology over the next decade, the United States will need more than one million additional STEM professionals than it will produce. This would require an annual increase of 34% in undergraduate STEM degrees over the next decade to meet the projected need for STEM professionals. It is imperative that the United States expand the STEM pipeline in order to meet the rapidly expanding STEM workforce needs and stay competitive with its international counterparts (Chen, 2009; Griffith, 2010; Halpern, Aronson, Reimer, Simpkins, Star & Wentzel, 2007; Hill, Corbet & Rose, 2010; US Department of Labor, 2007). Global business leaders are concerned that an inferior science and technology infrastructure could lead to an economic and technological vulnerability as serious as that posed by any military or terrorist threat (Business Higher Education Forum, 2005).

It is also important to make note of the number of jobs that are not classified as "STEM" but require high levels of familiarity with STEM knowledge. According to the National Science Foundation's (NSF) 2018 Science and Engineering Indicators, in addition to the 6.7 million members of the STEM workforce, there are another 19.4 million workers whose jobs, while not classified as STEM, require a certain amount of STEM expertise (NSF, 2018). Therefore, increasing the pipeline of graduates with STEM degrees will impact a much larger portion of the U.S. workforce than the jobs in STEM fields alone.

Despite growing demands for more STEM-educated employees, women and minorities are currently an underutilized source of intellectual capital that could fill the need in STEM-related careers. The STEM field in the United States remains primarily male and white (Bottia, Stearns, Mickelson, Moller, & Parker, 2015). Despite accounting for half of the college-educated workforce in the United States, only about one-third of earned STEM degrees are awarded to women (Duran & Lopez, 2010). Furthermore, minority women in STEM fields are even more scarce, earning only about 11% of STEM bachelor's degrees based on 2010 NSF data, despite representing approximately 20% of the college-aged population on 2010 (Duran & Lopez, 2015; Espinosa, 2011).

The percentage of various racial/ethnic groups across STEM occupations has shown no increase since the early 2000's, with the exception of Asians who have increased their share of the STEM workforce (NSF, 2018). While Hispanics, blacks, and American Indians/Alaska Natives account for 27% of the U.S. workforce, they comprise only 11% of employees in science and engineering fields (NSF, 2018). On the flip side, Asians account for 21% of those employed in science and engineering fields, despite only making up 6% of the total U.S. workforce.

In addition to tapping into this underutilized segment of our population, creating equity across genders and racial/ethnic groups in STEM fields offers additional benefits, including opportunities for increased financial stability for women and minorities, as well as inclusion of more diverse perspectives in STEM fields. Median earnings for those with STEM degrees or people working in STEM industry jobs are more than double the median earnings for the total U.S. workforce (Duran & Lopez, 2015). Jobs in STEM fields have also shown more security than other occupations with regard to unemployment rates (Duran, 2015). In addition to promoting equality of opportunity across gender and race/ethnicity in STEM fields, researchers point to a crucial need for diversity in backgrounds, experiences, and perspectives in the STEM workforce in order to cultivate scientific discovery and innovative solutions to global issues in the 21st century (Duran & Lopez, 2015; Espinosa, 2011; Hall, Nishina, & Lewis, 2017).

Efforts to expand the number and diversity of those in STEM fields need to start early on in students' academic careers. A STEM degree is essential to pursuing a career in a STEM field. Prior to earning a STEM degree, a student must first choose to pursue a STEM major. Thus, a starting point in expanding the STEM pipeline is developing an understanding of what factors influence selection of a STEM major. As students declare majors early in college, and, often, choose colleges based on majors they are interested in pursuing, it is important to look at expanding the STEM pipeline prior to students' enrollment in college.

In particular, the role of Advanced Placement (AP) course-taking in high school as a potential factor in expanding the STEM pipeline is worth examining. The AP Program offers high school students the opportunity to enroll in college level coursework and earn college level credit. Nearly 2.7 million students currently participate in the AP program, which is offered in almost 80% of U.S. high schools (Malkus, 2016). The AP program has been linked to college achievement, retention, and completion (Klopfenstein, 2004). With such a high rate of participation in the AP program across the nation, there is potential to utilize AP STEM course-taking as a means of expanding and diversifying the STEM pipeline if research shows enrollment in AP STEM courses is linked to pursuit of a STEM major.

Unfortunately, little is currently known about optimal patterns of AP course-taking in STEM subjects. What is known is that participation rates in AP STEM courses vary greatly across genders and racial/ethnic groups. White and Asian students have the highest participation rates in AP STEM courses while black and Hispanic students have the lowest participation rates (Ackerman, Kanfer, & Calderwood, 2013; Mattern et al., 2013). Additionally, data trends indicate that a higher percentage of males than females take AP math and physical science exams while the reverse is true for AP life science exams (Mattern et al., 2011). If optimal pathways of AP course-taking that are highly associated with pursuit of a STEM major can be determined, such information could be shared with stakeholders at the high-school level to help make programmatic decisions and effectively counsel students who wish to pursue a STEM major, especially women and minorities who are currently underrepresented in both AP STEM courses and STEM fields.

In past studies, researchers have found that student background characteristics, high school experiences, education aspirations, and early college experiences all contribute to college major selection (DeBoer, 1984; Ma, 2009; Moakler & Kim, 2014; Trusty, 2002; Wang, 2013). Studies are limited in several ways in examining specifically whether advanced high school course-taking influences student major selection. First, findings have not been consistent with regard to whether AP course-taking in STEM fields increases the likelihood of selecting a STEM major in college (Kuhn, 2015; Mattern, Shaw, & Ewing, 2011; Morgan & Klaric, 2007, Morgan & Maneckshana, 2000; Robinson, 2003; Tai, Liu, Almarode, & Fan, 2010; Morgan & Maneckshana, 2000; Robinson, 2003; Sadler, Sonnert, Hazari, & Tai, 2014; Tai, Liu, Almarode, & Fan, 2010). Second, among those studies on STEM major choice, only a few examined the relationship of AP STEM course-taking and STEM major selection. Limitations to these studies include inconsistent findings, relatively small samples (regional rather than national) in most cases, and a lack of studies looking at variation across racial/ethnic groups and genders. A larger sample with longitudinal data collected from a variety of sources (transcripts, students, parents) that examines variation by race/ethnicity and gender would provide more relevant data on student educational experiences that may influence their selection of a STEM major.

My study sheds light on the ways in which educators and policymakers can help guide students and shape policies and programs related to AP STEM course-taking that can increase the likelihood of selecting a college STEM major and also increase the presence of underrepresented women and minorities in STEM fields. Research uncovering AP pathways that increase the likelihood of STEM major selection in college can equip educational leaders and counselors at the high-school level who guide students in course selection and program decisions. Furthermore, identifying how the relationship of different AP pathways and college major selection varies by gender and race/ethnicity will also inform decision-making to help equalize opportunity and representation of currently underrepresented groups in the AP program and STEM fields.

Overview of this Study

This study develops a model of STEM major selection, with AP STEM course-taking as a key factor, using a combination of Lent, Brown, and Hackett's (2000) social cognitive career theory and St. John, Asker, and Hu's (2001) social construct theory as the conceptual framework. Social cognitive career theory provides a comprehensive model that takes into account both high school and college student-level factors with regard to selection of a STEM major or career, including high school math achievement, math and science course-taking, math self-efficacy, receipt of financial aid, faculty/student interaction, and degree aspirations (Moakler & Kim, 2014; Wang, 2013). Social construct theory, which includes high school context as a factor in major selection, accounts for the clustering of students in different high schools with different AP program offerings and different school characteristics. The sample for this study is taken from the High School Longitudinal Study of 2009 and includes students who were high school freshmen in fall 2009. Data was collected on these students during fall of their freshman year of in 2009, during the spring of 11th grade in 2012, and in the spring of 2016, three years after the majority graduated from high school.

The purpose of this study is to examine the relationship between AP STEM course-taking in high school and selection of college STEM major and whether the relationship differs across racial/ethnic groups and male and female students. The study develops a model of STEM major selection with AP STEM course-taking as the key factor, controlling for other factors that the literature documents as being significant predictors of STEM major selection. With the study results, we seek to help educators and policymakers shape college preparation programs and policies, as well as counsel students during their course selection process in high school. This study is guided by the following research questions: (1) After controlling for student background, high school experiences, and college experiences, how is AP STEM course-taking related to the likelihood of selecting a STEM major? (2) Does the relationship between AP STEM course-taking and STEM major selection differ by gender and race/ethnicity?

Organization of the Dissertation

Following the introduction in Chapter One, Chapter Two includes a comprehensive review of the literature, an overview of the AP program, and a critical review of theoretical frameworks utilized in STEM major selection studies, with an analysis of their advantages and limitations. The remainder of Chapter Two proposes a conceptual model and methodology for the current study. Chapter Three presents the research design, including the data source, sample, and research methods. Chapter Four provides a summary of the results of the data analysis as guided by the research questions. Finally, Chapter Five includes discussion and implications of the results as well as recommendations for future research.

Chapter II: Literature Review

The purposes of this literature review are as follows: (1) provide an overview of how STEM-related majors in college are defined; (2) provide an overview of AP programs; (3) critically review theoretical frameworks utilized in STEM major selection studies, addressing their advantages and limitations; (4) summarize and critique prior studies on AP STEM course-taking and choice of STEM fields and variables that account for choosing a STEM major; and (5) suggest an appropriate theoretical framework for my study to examine racial/ethnic and gender gaps in selection of a STEM major, with a particular focus on AP STEM course-taking as a key factor in reducing the gap.

Defining STEM

Before reviewing prior research and moving forward with the current study, it is important to have a clear understanding of how STEM (Science, Technology, Engineering, Mathematics) fields are defined. STEM covers a range of disciplines and is generally considered to include mathematics, physical sciences, biological/life sciences, computer/information sciences, engineering/engineering technologies (Chen & Weko, 2013; Chen, 2009). The National Center for Education Statistics (NCES) includes the following disciplines in its definition of STEM fields: agriculture and natural resources, architecture, biology and biomedical sciences, computer and information sciences, engineering and engineering technologies, health studies, mathematics and statistics, and physical sciences (Musu-Gillette, de Brey, McFarland, Hussar, Sonnenberg, & Wilkinson-Flicker, 2017). NCES further defines STEM occupations as including computer scientists and mathematicians; engineers and architects; life, physical, and social scientists; medical professionals; and managers of STEM activities (Musu-Gillette et al., 2017).

Non-STEM disciplines are everything outside of the aforementioned disciplines, which include business, education, English language and literature, foreign language and area studies, liberal arts and sciences, general studies, humanities, philosophy, theology and religious studies/vocations, psychology, social sciences, and history (Chen & Weko, 2013; Chen, 2009; Musu-Gillette et al., 2017). The National Science Foundation (NSF) (2018) uses a broader definition of STEM that actually includes social and behavioral sciences (anthropology, economics, psychology, and sociology). However, even NSF's recognition of the social sciences as part of STEM is inconsistent. Professionals in the social sciences have been excluded from NSF's program for Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program, and they are also not eligible for NSF's Research Experiences for Teachers program (Bray, 2010). Thus, there is a lack of consensus, even among professional and research organizations, on what disciplines are considered part of STEM. For the purposes of this study, and in agreement with prior studies examining predictors of STEM major selection (Robinson, 2003; Maltese & Tai, 2011; Wang, 2013; Bottia et al., 2015; Crisp, Nora, Taggart, 2009; Ackerman et al., 2013), I will be using the NCES definition that excludes social sciences from STEM disciplines.

Overview of Advanced Placement

As the relationship between AP STEM course-taking and STEM major selection is examined, it is important to have a clear understanding of the background and structure of the AP program. Established in 1955, the AP program is offered to high school students by an independent organization, the College Board, as a means of enrolling in college level coursework that culminates in exams, for which scores above a certain threshold can earn college credit or college course exemption (Bergeron & Gordon, 2017; Mattern, Shaw, & Ewing, 2011). The AP program offers high school students the opportunity to enroll in college level coursework in over 30 course offerings, 12 of which can be categorized as STEM subjects and include the following: Biology; Calculus AB; Calculus BC; Chemistry; Computer Science A; Computer Science Principles; Environmental Science; Physics 1; Physics 2; Physics C: Electricity and Magnetism; Physics C: Mechanics; and Statistics (College Board, 2017a). Out of nearly 5 million AP exams administered in 2017, approximately 1.6 million (nearly 33%) were administered in the aforementioned STEM subjects (College Board, 2017b).

Students may sign up for one or more individual AP course offerings based on what their high schools offer and any prerequisite entrance requirements (Mattern et al., 2011). More than 22,000 U.S. schools participate in the AP program with nearly 2.7 million students taking AP exams (College Board, 2017). A 2016 report estimates that the participation of U.S. public high schools in the AP program ranged from 71% to 79% over the years 2000-2012 (Malkus, 2016).

AP program participation has been linked to both college academic performance and completion. Ackerman, Kanfer, and Calderwood's (2013) analysis of Georgia Tech undergraduates 1999-2009 revealed that starting college with more AP exam-based credit hours was positively correlated to higher first year and cumulative GPAs. In another study of college freshmen in 1994 across 27 institutions, AP students had higher GPAs than non-AP students in the intermediate level courses they were placed into upon entry into college. This difference held its significance even after controlling for SAT score differences between AP and non-AP students (Morgan & Klaric, 2007). With regard to completion rates, the Georgia Tech study showed that both AP participation and increasing numbers of exams with scores of 3.0 or higher were correlated to higher college graduation rates when compared to graduation rates for students who did not take any AP exams (Ackerman et al., 2013). Similarly, in Morgan &

Klaric's study (2007), 63% of students who took at least one AP exam earned a degree within four years compared to 45% of non-AP students. The five-year graduation rates for AP and non-AP students were 77% and 62%, respectively. After controlling for SAT scores, AP students were 61% more likely to graduate than non-AP students.

While the existing research clearly shows a link between AP participation and college performance and completion, it is unclear to what extent AP course-taking may be related to major choice in college. This study examines whether the strength of the relationship between participation in STEM-related AP courses and subsequent STEM major selection at the college level. It also examines how the relationship differs across racial/ethnic groups and genders. If I can determine patterns of AP course-taking that lead to pursuit of a STEM major, particularly for currently underrepresented groups in STEM fields, such information can assist educators in providing opportunities as well as guide students toward opportunities that will expand the STEM pipeline.

Theoretical Perspectives

Developing a conceptual framework based on prior research to guide this study is essential prior to selecting predictors and control variables. The theoretical perspectives guiding research on college major and career selection include Krumboltz's social learning theory of career decision-making (Krumboltz, 1976); Lent, Brown, and Hackett's social cognitive career theory (Lent, Brown, & Hackett, 2000; Moakler & Kim, 2014); and St. John, Asker and Hu's (2001) student choice construct. Each theory asserts the influence of abilities, achievements, and skills on career choice (Trusty, 2002). Career development theories are included here because major choice has been shown to be closely linked to career choice and researchers have utilized such theories in studies on college major selection. The student choice construct model speaks to the relationship of school context and student choices made during college. Social cognitive career theory and social learning theory of career decision-making have both been previously utilized in studies focusing on STEM-career choice and major selection (Moakler & Kim, 2014). The student choice construct has not been widely applied to STEM major selection; however, it has been utilized in studies examining student decision-making at the college level (Engberg & Wolniak, 2013; Wolniak & Engberg, 2010). I will provide an overview of each theoretical perspective along with its limitations and strengths.

Social learning theory of career decision making

Krumboltz's social learning theory of career decision-making emphasizes the development of skills through learning experiences. Krumboltz suggests that different students interact with their environment in different ways, leading them to decisions regarding their educational and career paths (Krumboltz, 1976; Trusty, 2002). According to Krumboltz, a student's learning experiences, which include high school courses as well as extracurricular and leisure activities, lead them to make observations and judgments about their own performance as well as to develop skills to adapt to their environment. Together, observations about their learning environment and skills developed aid students in taking career-related actions, which include decisions regarding course-taking in high school and choice of major in college (Mattern et al., 2011; Trusty, 2002).

Findings from several studies have been consistent with Krumboltz's theory, showing a correlation between high school math and science course-taking and choice of a subsequent STEM-related college major (Davenport, Davison, Kuang, Ding, Kim, & Kwak,1998; Eccles, 1994; Maple & Stage, 1991; Ware & Lee, 1988). However, it should be noted that there are differences in how Krumboltz's theory holds for women and men in these studies. Generally, findings indicate that course-taking is a more influential factor for women, whereas self-performance observations are a more influential factor for men (Trusty, 2002).

Researchers have extended this theoretical perspective to specifically examine the effect of math and science course-taking at the AP level on selection of a college STEM major (Ackerman et al., 2013; Mattern et al., 2011; Morgan & Klaric, 2007; Robinson, 2003; Smith, Jagesic, Wyatt & Ewing, 2018). Findings indicate that the level of math and science coursework, not just the number of courses taken, affect a student's likelihood of choosing a STEM major.

Social cognitive career theory

Lent, Brown, & Hackett's social cognitive career theory, widely used in STEM-related studies to examine choice of STEM career, major, and courses (Betz & Hackett, 1983; Byars-Winston, Estra, Howard, Davis & Zalapa, 2010; Hackett, Betz, Casas, & Rocha-Singh, 1992; Lent, Lopez, & Bieschke, 1993; Lent, Lopez, Lopez, & Sheu, 2008; Lent, Sheu, Gloster, & Wilkins, 2010), points to an interrelationship between individual, environmental, and behavioral factors that influence one's academic major and career choice (Hall, Nishina, & Lewis, 2017; Maltese & Tai, 2011; Wang, 2013). In particular, using social cognitive career theory, both the role of 12th grade math achievement and exposure to math and science courses are found to be important in affecting one's choice to major in a STEM field (Moakler & Kim, 2014). Wang's study found additional factors at both the secondary and postsecondary levels that also played a role in choosing a college major (Wang, 2013). Wang's (2013) study utilized data from the Educational Longitudinal Study of 2002 (ELS:2002), a nationally representative study of 10th graders in 2002 that follows them for eight years after expected high school graduation. High school math achievement, exposure to math and science courses, math self-efficacy beliefs, receipt of financial aid, and degree aspirations were all found to be positively correlated to choosing a STEM major (Wang, 2013).

In addition to Wang's (2013) findings, self-efficacy has been found in numerous studies examining social cognitive career theory to be a significant driver in college achievement. STEM-related self-efficacy, in particular, has been found to be a contributing factor in decision-making regarding pursuing a STEM field of study and, in several studies, has been found to be equally as important for men and women of all races/ethnicities (Hall, et al., 2017; Wang, 2013; Lent, Brown, & Hackett, 2000; Bandura, 1977, 1982; Betz & Hackett, 1981).

In testing their model, Betz and Hackett (1981) asked 134 female and 101 male undergraduates to indicate their perceptions of their capabilities to successfully complete the educational requirements and job duties of each of 10 traditionally female and 10 traditionally male occupations. Respondents were also asked to indicate their level of interest in and extent of consideration of each occupation. Results indicated that self-efficacy played a role in the different careers being considered by women but it did not play a role in careers considered by men. In addition, women had lower self-efficacy expectations with regard to mathematics, which led them to consider different, non-STEM related, career choices than did men (Betz & Hackett, 1981).

St. John, Asker, and Hu's student choice construct

St. John, Asker, and Hu's (2001) student choice construct draws from cultural, social, and economic capital theories, asserting that student aspirations, educational choices, and academic growth are influenced not only by family background characteristics but also the K-12 educational setting (Engberg & Wolniak, 2013; Wolniak & Engberg, 2010). Thus, certain high school contexts may influence student choices at the college level, including major selection

(Engberg & Wolniak, 2013; St. John, Asker, & Hu, 2001; Wolniak & Engberg, 2010) St. John et al.'s (2001) student choice construct further suggests a relationship between institutional, state, and federal policies regarding access to fields of study and student choices related to educational outcomes (e.g. major selection).

Prior research has looked specifically at the influence of high school context on a student's college choice (McDonough, 1997). McDonough's (1997) qualitative study of twelve high school seniors across four schools revealed that the high school context played a role in the type of postsecondary institution the students chose to attend. Hill (2008) utilized data on 10th graders from the High School Effectiveness Study (HSES) and found that school-level resources had a direct effect on students' college enrollment decisions. HSES was conducted in conjunction with NELS:88 and its sample includes longitudinal school and student samples for the 30 largest Metropolitan Statistical Areas (Hill, 2008). Engberg and Wolniak (2013) applied the student construct theory to their study of student STEM major selection using ELS:2002 data. While they did not find any of their selected high school institutional factors (sector, region, extent to which high school helped students select majors/career pathways, extent to which students were involved in college preparation programs, physical condition of the learning environment, number of math and science teachers) to be significant predictors of STEM major selection, it is possible that other institutional factors that may have significance were not included, such as AP STEM offerings, which are worth examining (Engberg & Wolniak, 2013).

St. John, Asker, and Hu's model includes a relevant component to my study that is not included by Krumboltz or Lent, Brown & Hackett: high school characteristics such as course and program offerings as well as environmental factors such as urbanicity, economic composition of the school, and size of the school. Controlling for secondary school-level factors will be important in my study in order to fully examine the research questions.

Summary & limitations of theoretical frameworks

While each of the three aforementioned theories or conceptual frameworks has been used in prior studies to explain decision-making as it relates to choice of a STEM-related career or major, limitations to these models exist. Krumboltz's social learning theory emphasizes course-taking, the key factor in my study; however, his model does not include self-efficacy, a factor that has been shown to significantly influence choice of major for both men and women (Good, Aronson, & Harder; 2008; Fryer & Levitt, 2010; Penner & Paret, 2008; Riegle-Crumb, King, Grodsky, and Muller, 2012; Stevens, Wang, Olivarez, & Hamman, 2007). Lent, Brown, & Hackett's social cognitive career theory provides a comprehensive model that takes into account both high school and college factors with regard to selection of a STEM major or career. The main limitation of this model is that it only includes student-level factors and does not account for any institution-level factors (Wang, 2013). St. John, Asker, and Hu's student choice construct accounts for both student-level and institution-level factors, including high school context, as a component in the model. Since the students who comprise my study's sample are nested within different high schools, it is important to consider school-level factors in addition to individual factors.

Review of Prior Literature: Student- and School-Level Factors Influencing College Major Selection

Findings from a number of empirical studies support the previously discussed theories and actualize the frameworks put forth in the theories, providing us with a better understanding of the factors that influence college major selection. In addition to the observed student-level characteristics that influence STEM major selection, I also must account for the fact that students are clustered within different schools (Clarke, Crawford, Steele, & Vignoles, 2010). Therefore, school-level characteristics must also be considered as they may influence both the likelihood of a student taking an AP STEM course, the key factor in this study, as well as the likelihood of a student selecting a STEM major in college. Thus, this section first summarizes student-level factors influencing a student's choice of a college STEM major in three broad categories: student background characteristics, high school student experiences, and college student experiences. Next follows a summary of high school-level factors that may influence both AP STEM course-taking and STEM major selection.

Student-level factors influencing STEM major selection

Following is a review of prior literature on student-level factors related to STEM major selection, including student background characteristics (gender, race/ethnicity, socioeconomic status [SES]), high school experiences (total number of STEM courses, AP STEM course exposure, math and science self-efficacy, academic achievement, education aspirations) and college student experiences (receipt of need-based financial aid).

Student background characteristics

Gender. Generally, empirical studies have found that gender is one of the most robust predictors of choice of college major (Crisp et al., 2009). A study looking at first-year college students between 1995-2001 found that 33% of men enter STEM fields compared to 14% of women, especially in math, engineering, and computer science (Chen, 2009). A study on graduates from Hispanic Serving Institutions (HSIs) between 2006 and 2008 indicated women were less likely than men to declare a STEM major (Crisp et al., 2009), which was consistent with Mau's (2016) findings about Midwest undergraduate students enrolled between 2008-2013.

Being female was also found to be a significant negative predictor of STEM major choice using nationally representative data of more than 300,000 college freshmen in 2003 from the Cooperative Institutional Research Program (CIRP) (Moakler & Kim, 2014).

Results from analysis of National Educational Longitudinal Study of 1988 (NELS:88) data supported previous findings that overall men were more likely to enter STEM fields than women (Ma & Liu, 2017). However, the choice of STEM major varies across STEM sub-categories. Life sciences had a higher female presence than men, whereas physical sciences had a very low female presence (Ma & Liu, 2017). Studies have continued to show that overall women are less likely to choose a STEM major.

Some researchers argue that this may be due to the current culture and climate in STEM fields, which are male-dominated and unwelcoming to women (Banchefsky & Park, 2018; Ma & Liu, 2019). Researchers suggest the masculine culture in male-dominated STEM fields is defined by a set of norms, values, and beliefs that ostracize women (Cheryan et al., 2016). These cultures are defined by a lack of female role models and stereotypes about the inferiority of the women's abilities in the sciences (Carli et al., 2016). Banchefsky and Park's (2018) study of 2,622 undergraduates at a public American university showed that men enrolled in male-dominated academic majors (e.g. STEM majors in the physical sciences) were more likely to endorse the notion that women should conform to masculine norms if they pursued a male-dominated field, and they believed that women should pursue what are considered traditionally female roles and careers. These beliefs help to sustain a culture in STEM fields that continues to discourage women to enter, suggesting that more work needs to be done to encourage and support women in pursuing STEM fields as early as high school (Banchefsky & Park, 2018; Ma & Liu, 2019).

Race/ethnicity. Race/ethnicity is a salient factor in college major selection. Findings from the National Longitudinal Survey of Youth (NLSY79) and the High School & Beyond National Longitudinal Study of 1980 (HS&B), though not STEM specific, support that race/ethnicity is a significant predictor of college major (Caputo, 2004; Ethington & Wolfle, 1988).

Underrepresented minority status was positively associated with STEM major choice in a study using survey data from over 300,000 college freshmen as part of the Cooperative Institutional Research Program (CIRP) (Moakler & Kim, 2014). In a study that examined characteristics of college students who entered STEM fields between 1995 and 2001, Asian/Pacific Islander students were far more likely to enter STEM fields than any other racial/ethnic groups (Chen, 2009). However, no significant differences were found between white, black, and Hispanic students (Chen, 2009). Similar to the findings of previous research, a study of Midwest undergraduate students enrolled between 2008-2013 revealed that significantly more Asian students declared a STEM major than white, black, or Hispanic students. Additionally, female minority students were less likely than white or male students to declare a STEM major (Mau, 2016). Data from Hispanic Serving Institutions (HSI) showed the odds of declaring a major in STEM were 1.37 times higher for Hispanic students and 1.93 times higher for Asian students as for white students (Crisp et al., 2009).

Socioeconomic status (SES). While socioeconomic status (SES) has been linked to college major selection preferences, findings of empirical literature have not been consistent regarding major preferences of students from more advantaged or less advantaged backgrounds (Ethington & Wolfle, 1988). A study looking at first-year college students between 1995-2001 found students with more advantaged family background characteristics were more likely to enter STEM fields than other students while NELS:88 data showed the exact opposite (Chen, 2009; Ma, 2009). According to NELS:88, students from a higher SES were more likely to choose humanities/arts while students from a lower SES were more likely to choose a technical, business or life/health field. However, some research suggests students from more advantaged backgrounds may be more inclined to pursue a STEM field because they have the resources to pursue the rigorous STEM coursework, which often requires additional years of schooling (Chen, 2009). Others also argue that the decision to major in STEM for more economically advantaged students is a result of cultural norms and expectations (Brand & Xie, 2010). Regarding the contradictory findings, researchers suggest students from a higher SES may not be as concerned about job prospects as students from a lower SES. Thus, students from a lower SES may be more likely to select STEM-related majors as they are looking to pursue majors that will guarantee more lucrative job opportunities (Ma, 2009).

Summary. A student's gender, race/ethnicity, and SES have all been linked to college major choice. Overall, men have been found to be more likely to select STEM majors (Crisp et al., 2009; Mau, 2009; Ma & Liu, 2017). Numerous studies have shown Asian students are the most likely racial/ethnic group to pursue a STEM field (Mau, 2016; Crisp et al., 2009). The findings regarding SES as a predictor of STEM major selection vary across studies, with some finding higher SES a positive predictor and others finding lower SES a positive predictor.

High school student experiences

Total number of high school STEM courses. A number of studies have shown that the number of STEM courses taken in high school was positively associated with selection of a college STEM major (Maple & Stage, 1991; Ethington & Wolfle, 1988; Chen, 2009; Bottia et al., 2015; Trusty, 2002). In Ethington and Wolfle's (1988) study using data from the High School and Beyond (HS&B) longitudinal study of 1980, high school courses taken in math and science were the most significant factors in the model. A study of University of North Carolina freshmen found that high school courses taken in physics and biology were closely associated with STEM major selection in college (Bottia et al., 2015). In Trusty's (2002) study using National Educational Longitudinal Study of 1988 (NELS:88) data, when controlling for background variables, the effects of taking trigonometry, pre-calculus, and calculus were all significantly positively correlated with STEM major selection for women. NELS:88 is a nationally representative, longitudinal study of 8th graders in 1988 and follows them all the way up to eight years after expected high school graduation. Trusty's (2002) analysis of NELS:88 data showed that taking one unit in trigonometry increased the likelihood of a woman selecting a STEM major by 64%, one unit in pre-calculus increased the likelihood by 48%, and one unit in calculus more than doubled the likelihood. The only high school course shown to have a significant positive correlation to STEM major selection for men was physics. Taking one unit in physics increased the likelihood of a man selecting a STEM major by 39% (Trusty, 2002). Results of a study investigating the effects of computer science education on student STEM major choices using a nationally representative sample of U.S. young adults who chose college majors by 2006 showed that high school computer science education was a strong predictor for student STEM major choices (Lee, 2015).

Exposure to AP STEM courses. Some studies have included participation in AP courses and AP test-taking as a possible predictor of STEM major selection. Results have shown a positive relationship between AP test-taking and selecting/persisting in a major in a related field in college, specifically in regard to STEM subjects (Dodd et al., 2002; Mattern et al., 2011; Morgan & Klaric, 2007; Morgan & Maneckshana, 2000; Robinson, 2003; Tai, Liu, Almarode, & Fan, 2010). A study of first-year college students at Georgia Tech between 1999 and 2009 found earning AP Calculus credit in high school and taking three or more AP exams in STEM courses were the two most important predictors of STEM major persistence (Ackerman, et al., 2013). Utilizing student data from eight high schools within a diverse school district, Robinson (2003) found that students who took AP courses in calculus or the sciences were more likely to major in STEM fields in college than students who did not take these courses.

Second year college performance data on the 2006 freshman class across 67 colleges and universities showed a similar relationship when looking at not only enrollment in AP courses but also actual AP test-taking after controlling for relevant student background characteristics (Mattern et al., 2011). A student who took one AP biology exam had approximately three times the odds of majoring in biological/biomedical sciences compared to a student who did not take this exam. The odds increased to six times more if a student took two AP biological science exams (Mattern et al., 2011). A student who took one AP computer science exam had 4.5 times the odds of majoring in computer science compared to a student who did not take an AP computer science exam, with the odds increasing to 9 times more for a student who took two AP computer science exams. While the odds of majoring in math/physical science were only 1.5 times more for a student who took one AP math/physical science exam than a student who did not take any exams, the effect increases as a student takes more exams in this area (Mattern et al., 2011). These results suggest that as the number of AP exams in STEM subjects a student takes increases, so does the likelihood of a student subsequently selecting a STEM college major.

In contrast, Sadler, Sonnert, Hazari, & Tai's 2014 study showed different results when examining factors influencing STEM major intentions among 4,500 first year college students across 34 institutions. Their study found that while taking calculus, physics, or a second year of chemistry were correlated to increased likelihood of STEM major selection, taking AP courses in science or calculus showed no additional significant impact on increasing likelihood of STEM major selection over other advanced, non-AP courses. The study showed that while taking advanced coursework in math/science in high school increased the odds of interest in a STEM major among college freshmen, taking AP courses in these subject areas made no significant difference (Sadler, et al., 2014).

Prior research on the relationship between AP STEM course-taking and STEM major selection is lacking in several ways. Most studies utilize single institution data or data from a group of institutions rather than a national dataset. Additionally, the studies varied in the outcome variables examined, which include persistence, initial interest in a STEM field upon entering college, and selection of a college major after two years of enrollment. Finally, there are inconsistent findings with regard to whether or not AP STEM course-taking is positively associated with pursuing a STEM field/major.

Math and science self-efficacy. A positive attitude toward math and a belief in one's abilities in math was positively related to the choice of STEM major in the literature (Ma, 2009; Moakler & Kim, 2014; Hackett, 1985). Carlone and Johnson's (2007) ethnographic study of 15 women of color in STEM careers revealed that self-efficacy was a particularly important predictor for choosing a STEM major. Utilizing HS&B data, a study found that women with positive math attitudes were more likely to choose a STEM major than women who did not possess positive math attitudes (Ethington & Wolfle, 1988). Two additional studies, one a single institution survey of 117 undergraduates and another study that used CIRP survey data, found self-confidence in mathematics ability was positively related to STEM major choice (Hackett, 1985; Moakler & Kim, 2014). Research on the relationship of science self-efficacy and STEM major selection is limited; it has not been measured and studied as widely as math self-efficacy.

However, in a study of 1,488 freshman students at a large southeastern public university, students who majored in a science discipline had a higher science self-efficacy (Forrester, 2010). This finding indicates that science self-efficacy may be a factor worth including in the examination of STEM major selection as it is a new variable included in HSLS:09 that was not included in any of the prior educational longitudinal studies.

Academic achievement. High school academic achievement, as measured by GPA, SAT and ACT, has been shown to be a positive predictor of pursuit of a STEM field for both men and women (Ma, 2009; Ware & Lee, 1988; Ware, Steckler, & Lesserman, 1985). Data from the 1995-1996 Beginning Postsecondary Students Longitudinal Study (BPS:96/01) and the 2003-2004 National Postsecondary Student Aid Study (NPSAS:04) indicate that students who earned a GPA of B or higher in high school and had college entrance exam scores in the highest quartile had a greater likelihood of entering STEM fields than students without these academic characteristics (Chen, 2009). A study on students at Hispanic Serving Institutions (HSIs) graduating between 2006 and 2008 found SAT math score and high school percentile significantly influenced choice of STEM major (Crisp et al., 2009). CIRP survey data as well as data on Midwest undergraduate students enrolled 2008-2013 also indicates that SAT/ACT score and high school GPA were positive predictors of declaration of a STEM Major (Mau, 2016; Moakler & Kim, 2014). Studies utilizing NELS:88 and more recent Educational Longitudinal Study of 2002 (ELS:2002) data confirmed the finding that high school math achievement was positively related to selecting a college STEM major (Ma, 2009; Wang, 2013).

Education aspirations. Past research has consistently shown a significant relationship between a student's degree aspirations and various college outcomes, including college completion, academic achievement, and even major selection (Khattab, 2015; Wang, 2013; Wu

& Bai, 2015). Ware & Lee (1988) concluded from HS&B data that high educational aspirations are positively related to selecting a STEM major for both men and women (Ware & Lee, 1988). According to Wang's (2013) findings, aspiration or earning a graduate degree was positively correlated to choosing a STEM major. Perhaps this holds true because students with high aspirations are better equipped to take on rigorous STEM coursework in their college career (Wang, 2013).

Summary. Prior research has shown several high school factors to be significant predictors of selection of a college STEM major. The number of STEM courses taken in high school has been positively correlated to STEM major selection (Bottia, Stearns, Mickelson, Moller, & Parker, 2015). However, the strength of the effect for men versus women has differed across STEM subjects (Trusty, 2002). In further examining whether it matters that the high school STEM courses are categorized as AP, findings have been inconsistent (Mattern et al., 2011; Sadler et al., 2014). A student's attitudes toward math and science, generally referred to as math and science self-efficacy, have been shown to be positively associated with pursuit of a STEM major (Ethington & Wolfle, 1988; Trusty, 2002). Additionally, high academic achievement as measured by GPA and SAT and ACT scores has consistently been linked to increased likelihood of STEM major selection (Ware & Lee, 1988; Ma, 2009). Finally, students with higher educational aspirations are more likely to major in a STEM field (Wang, 2013; Ware & Lee, 1988).

College student experiences

Receipt of need-based financial aid. Whether or not a student is eligible for/receives financial aid has been found to be an important factor related to the likelihood of a student selecting a STEM major (Kienzl & Trent, 2009; Wang, 2013). A study of Florida students who entered college in 2000 found that the eligibility for need-based financial aid increased STEM credit completion by 20-35 percent over students who were not eligible for such aid (Castleman et al., 2018). In another study examining ELS:2002 data, receipt of financial aid positively contributed to selecting a STEM major with race, gender, and SES controlled for (Kienzl & Trent, 2009; Wang, 2013). Results of two studies showed that the need-based Wisconsin Scholars Grant (WSG) increased the likelihood of recipients majoring in STEM (Anderson, Broton, Goldrick-Rab, & Kelchen, 2018; Broton & Monaghan, 2018). In the first of the two studies, grant recipients were 7.87 percentage points more likely to select a STEM major than non-recipients (Broton & Monaghan, 2018). The follow-up study looked at students who actually earned STEM degrees and found WSG recipients in 2008 and 2009 were 6.8 and 5.9 percentage points more likely to earn a STEM degree, respectively, than non-grant recipients (Anderson et al., 2018). Researchers suggest that perhaps offering more need-based aid induces more students with STEM interests to enroll in college who otherwise would not. Another possible reason for this relationship is that students pursuing STEM fields spend more time studying than students in other fields; therefore, financial aid receipt alleviates financial pressure, allowing students to meet the challenges presented by majoring in a STEM field, not having to work while pursuing their degree (Kienzl & Trent, 2009; Wang, 2013). Researchers also suggest that need-based aid may help to offset prohibitive costs for students related to purchasing expensive textbooks and lab supplies required for STEM majors (Broton & Monaghan, 2018).

School-level factors influencing STEM major selection

Prior research has shown a relationship between school-level factors and students' postsecondary pathways, which has direct implications for pursuit of a STEM major (Engberg & Wolniak, 2010; McDonough, 1997; Perna & Titus, 2005). Following is a discussion of school-level factors that prior literature has indicated are related to both student enrollment in AP STEM courses and to STEM major selection, including AP STEM courses offered and how that is influenced by percent free/reduced lunch, size of school, and urbanicity. Additionally, I will discuss other factors that have a possibility of influencing AP STEM course-taking and STEM major selection, but have not been examined due to a lack of data.

AP STEM Courses Offered. A lack of advanced/AP course offerings predetermines what college major choices and career paths will be available for students after graduating from high school (Gagnon & Mattingly, 2015; McKinney, 2014). AP program participation by U.S. high schools has greatly expanded since the program began: starting in 1955 with 105 high schools, it has grown to include more than 22,000 high schools, which represents approximately 79% of all U.S. high schools (College Board, 2017). However, over 20% of high schools still do not afford students the opportunity to enroll in AP courses. It is likely that an even greater percentage of schools do not offer AP STEM courses given the difficulty of finding qualified STEM teachers due to the limited STEM pipeline. According to a 2016 report by the Center for Public Education, schools across the United States report that math and science teaching positions are the hardest to fill. This must be taken into account and controlled for when determining the likelihood of a student enrolling in an AP STEM course and, ultimately, selecting a STEM major.

Research indicates that schools with lower enrollment and higher percentages of students receiving free and reduced lunch are more likely to have fewer advanced/AP STEM course offerings (Barnard-Brak, McGaha-Garnett, & Burley, 2011; Robinson, 2003; Monk & Haller, 1993; Anderson & Chang, 2011; Ballard, 2018; May & Chubin, 2003; Theokas & Saaris, 2013). Additionally, past empirical studies have consistently shown that rural students have significantly less access to advanced/AP math and science courses than students in more urban areas (Gagnon & Mattingly, 2015, McKinney, 2014; Anderson & Chang, 2011).

Other School-level Factors. Prior research indicates additional school-level factors that have not been widely measured that may also contribute to the likelihood of AP STEM course-taking and STEM major selection, including teacher quality, college counseling, school culture, and STEM-related club and competition opportunities. Crisp et al. looked at determinants of STEM career choice and found that respondents ranked appropriate instructional environment first (Crisp et al., 2009). A 2016 study of factors influencing Turkish and American students' pursuit of a STEM career found that opportunities to participate in STEM-related clubs and competitions, teacher effectiveness, and the knowledge level of college counselors all affected the likelihood of American students selecting a STEM career (Bahar & Adiguzel, 2016). While not STEM-specific, additional research clearly indicates that clustering often occurs in educational studies looking at student outcomes across different schools because of the influence of unmeasured school characteristics such as teacher quality and school ethos (Clarke, Crawford, Steele, & Vignoles, 2015).

Summary. While research on AP STEM program offerings at the high-school level and their relationship to student pursuit of a STEM major is lacking, the aforementioned research indicates a need to account for nesting of students within different high school settings when examining the individual factors related to STEM major choice (Engberg & Wolniak, 2013). It would be much less meaningful to examine the relationship between AP STEM course-taking at the high-school level and STEM major selection without also considering school-level factors that may influence AP STEM course-taking and STEM major selection. A student's high school characteristics predetermine a path regarding what college major choices and career paths will be available for students after graduating from high school (McKinney, 2014; Gagnon & Mattingly, 2015). Thus, it is important that the methods utilized in my study account for both observed and unobserved school-level factors that may affect the likelihood of enrolling in an AP STEM course, the key factor of this study, and STEM major selection.

Limitations of prior studies

The empirical studies reviewed in this section have identified and examined the relationship of student background characteristics, high school experiences, and college experiences with college major selection, with a particular focus on STEM-related majors. However, only a few studies have utilized a comprehensive model that includes both high school and early college experiences in their examination of student major selection (Wang, 2013; Evans, 2013; Maltese & Tai, 2011). A study examining both high school and college factors together would provide a more comprehensive picture of the predictors that significantly contribute to college STEM major selection.

Researchers have identified high school course-taking as a significant predictor of college STEM major selection (Maple & Stage, 1991; Ethington & Wolfle, 1988: Chen, 2009). The limited studies that have examined the actual level of the courses, including whether the courses are classified as Advanced Placement, have only looked at subgroups of schools, utilizing College Board regional data or single institution data (Ackerman et al., 2013; Hoepner, 2010; Mattern, Shaw, & Ewing, 2011; Morgan & Klaric, 2007; Robinson, 2003; Smith et al., 2018). Existing research lacks a study utilizing a national dataset with findings that can be generalized beyond the sample in the study. Additionally, prior studies have primarily looked at AP exam participation and performance as a predictor, not AP course-taking (Ackerman et al., 2013; Hoepner, 2010; Mattern, Shaw, & Ewing, 2011; Morgan & Klaric, 2007; Robinson, 2003; Smith et al., 2018). Identifying AP STEM course-taking patterns rather than just AP exam participation and performance as a predictor of STEM major selection will inform high school administrators and guidance counselors, parents, and students regarding the implications of course selection regardless of a student's ultimate decision to take the AP exam and subsequent score performance on the exam at the culmination of the course.

Gender and race/ethnicity have also been linked to enrollment in AP math and science courses. However, research is lacking on whether the relationship between AP STEM course-taking and STEM major choice may vary by gender and race/ethnicity. While Morgan and Klaric's study examines how the relationship of AP STEM course-taking and STEM major selection differs across racial/ethnic and gender subgroups, the sample of the study is comprised of incoming freshmen in only 27 colleges more than 20 years ago.

The influence of high school context on STEM major selection has not been accounted for in prior studies. While research has shown that school-level characteristics, such as AP STEM course offerings, vary widely across school contexts, studies have yet to account for the relationship between high school context and STEM major selection. Prior longitudinal studies have not looked at multiple levels of data, failing to recognize that students are clustered within different educational institutions with different contexts.

Another limitation of prior research is that the majority of the more recent studies utilize a regional or single institution dataset. With the exception of Wang's (2013) and Maltese and Tai's (2011) studies, which used ELS:2002 data, analysis using national databases is much older, examining data on students who graduated college 20-30 years ago. Even the base year of ELS data is 16 years old, including a cohort of students that may not be representative of the current student population. Furthermore, STEM is an evolving field that has seen significant growth and change at the high school and college levels as well as the workforce since ELS data collection began. HSLS:09 Second Follow-up data was released in June 2018. In addition to including a more recent cohort of students, HSLS:09 also includes more STEM-focused data, including measures of math and science self-efficacy, exposure to STEM through home or school activities, and negative school and STEM experiences. Research utilizing a more recent longitudinal dataset with a particular focus on STEM learning experiences and outcomes such as HSLS:09 would provide findings more relevant to today's educational landscape and STEM workforce needs.

Overview of This Study

Based on the review of past empirical research, a study examining high school and college factors together helps provide educators and policymakers with a better understanding of the predictors that could significantly contribute to college STEM major selection. Findings can assist educators at the secondary and post-secondary levels in working together to support entrance into the STEM pipeline. This study focuses on AP STEM course-taking as a predictor of STEM major selection, examining how student experiences as well as student background characteristics can inform policymakers and educators regarding allocation of resources and program and policy decisions to expand inclusion of currently underrepresented groups — women and minorities — in STEM fields.

The model for this study incorporates the student-level high school and college factors accounted for in Lent, Brown, and Hackett's (2000) social cognitive career theory as well as the school-level factors as per St. John, Asker, and Hu's (2001) student choice construct. With this model, the study examines the relationship between AP STEM course-taking and selection of a STEM major when controlling for race, gender, socioeconomic status, high school course-taking, math and science self-efficacy, academic achievement, receipt of need-based financial aid, faculty/student interaction, education aspirations, and selection of a college STEM major. Racial/ethnic and gender gaps in STEM major selection are examined along with the role AP STEM course-taking may play in reducing any gaps that exist.

Chapter III: Research Design

The purpose of this study is to examine the relationship between AP STEM course-taking in high school and selection of college STEM major and determine whether the relationship differs across racial/ethnic groups and male and female students. The study develops a model of STEM major selection with AP STEM course-taking as the key factor, controlling for other factors that the literature documents as being significant predictors of STEM major selection. With the study findings, we seek to provide insight to educators and policymakers in shaping college preparation programs and policies as well as counsel students during their course selection process in high school. This study is guided by the following research questions: (1) After controlling for student background, high school experiences, and college experiences, how is AP STEM course-taking related to the likelihood of selecting a STEM major? (2) Does the relationship between AP STEM course-taking and STEM major selection differ by gender and race/ethnicity?

Research Model

The conceptual model for this study is based on a combination of Lent, Brown, and Hackett's (2000) social cognitive career theory and St. John, Asker, and Hu's (2001) social construct theory as presented in Chapter Two. This conceptual model incorporates both student-level and institution-level factors, and is the framework for the two-level logistic regression model with fixed effects used in this study.

The major constructs in the proposed STEM major selection model include:

- Student background characteristics (gender, race/ethnicity, socioeconomic status)

- High school student experiences (total number of high school STEM courses, exposure to AP STEM courses, math self-efficacy, science self-efficacy, academic achievement, education aspirations)
- College student experiences (receipt of need-based financial aid)
- High school context (high school ID). There are likely unobserved school-level characteristics affecting the likelihood of both AP STEM course-taking, the key factor, and STEM major choice. Therefore, I will be utilizing high school ID, rather than the individual school-level characteristics discussed in the literature review, to account for all school-level factors in my model. The use of high school ID as a fixed effect will be discussed in more detail later in the chapter.

Data Source and Sample

The High School Longitudinal Study of 2009 (HSLS:09) is utilized as the data source for this study. HSLS:09 is the fifth survey in a series of educational longitudinal studies that include the Educational Longitudinal Study of 2002 (ELS:2002), the National Educational Longitudinal Study of 1988 (NELS:88), the High School & Beyond Longitudinal Study of 1980 (HS&B), and the National Longitudinal Study of the High School Class of 1972 (NLS-72). HSLS:09 data collection is ongoing, with base year, first follow-up, and second follow-up data currently available on the NCES website (Duprey, Pratt, Jewell, Cominole, Fritch, Ritchie, Rogers, Wescott, Wilson, 2018). These five studies capture data on the secondary and postsecondary experiences of cohorts of students representing each of the past five decades. The overall purpose of the longitudinal studies program is to examine the relationship of personal, family, social, institutional, and cultural factors with the personal, educational and career development of students (Duprey et al., 2018).

The HSLS:09 baseline survey is representative of high school freshmen in fall 2009 who were followed up with two years later during the spring of 11th grade (first follow-up), the summer after the majority graduated from high school (2013 update), and in the spring of 2016, three years after the majority finished high school (second follow-up). Unlike earlier NCES longitudinal studies, HSLS:09 has a particular focus on STEM learning experiences and outcomes with the intention of helping researchers and policymakers investigate the nature of paths into and out of the STEM pipeline and what personal and educational factors influence those decisions. Thus, HSLS:09 presents a unique opportunity for this study to examine factors related to selection of a STEM major.

The base year survey in fall 2009 included a random sample of 25,206 high school freshman from 944 public and private high schools across the United States. Student participants completed a survey and a mathematics assessment. The student survey collected information on a variety of topics, including student background, math and science course-taking, math and science self-efficacy, and educational and career aspirations. Each student’s parent, science and mathematics teachers, and school counselor all completed questionnaires. An administrator from each school included in the survey also completed a questionnaire (Duprey et al., 2018).

The first follow-up data collection once again included student, parent, counselor, and administrator questionnaires, which included many of the same topics as the base year surveys. The 2013 update was utilized to collect high school transcripts and survey students and parents regarding high school completion status. The second follow-up survey administered questionnaires to students only, inquiring into students’ postsecondary, employment, and personal experiences. Postsecondary transcripts and financial aid records from institutions that students in the sample attended were also collected as part of the second follow-up. It is important to note that the base year, first follow-up, and second follow-up surveys all collected information regarding decision-making on education and careers related to STEM fields (Duprey et al., 2018). HSLS:09 was designed with the intent to study student access to and participation in STEM courses as well as their decisions to pursue and persist in STEM majors and careers.

HSLS:09 was designed utilizing two earlier NCES longitudinal studies, namely NELS:88 and ELS:2002, as a model; however, HSLS:09 also included design updates to improve upon the earlier studies. Similarities to earlier NCES studies can be found in the development of scales for composite variables in HSLS:09, such as socioeconomic status, math self-efficacy, and science self-efficacy. To further ensure validity and reliability, their development was also based on advice received from HSLS:09 Technical Review Panel (TRP) members and TRP meeting participants (Ingels, Pratt, Herget, Dever, Fritch, Ottem, Rogers, Kitmitto, & Leinwand, 2014).

However, there are also key differences between HSLS:09 and earlier NCES longitudinal studies. HSLS:09 adjusted timeframes of data collection to improve the quality of the data collected. For example, the second follow-up data collection occurred three years after expected high school graduation rather than two as in prior studies. Doing so allowed for more complete and accurate collection of data on postsecondary education experiences (persistence, majors, etc.) as students had more of their college experience under their belts (Duprey et al., 2018). It should be noted that cross-cohort comparisons cannot be made with earlier NCES secondary longitudinal studies due to new measurement points. However, the improvement in data quality due to the improved design of HSLS:09 and the focus on STEM education and careers is a worthwhile trade-off.

Research Variables for STEM Major Selection Model

Outcome variable

The outcome variable in this study is a dichotomous variable indicating whether a student chose a STEM or non-STEM major after up to two years of college enrollment at a four-year institution. The college major variable is recoded so that all STEM majors are recoded as 1 and all other majors, including undecided, are recoded as 0.

Independent variables

- Student background characteristics
- Gender (this categorical variable indicates a student's gender. This variable is recoded into a dichotomous variable with Female as the reference group.)
- Race/ethnicity (this categorical variable indicates a student's race/ethnicity. White students are the reference group.)
- Socioeconomic status (this continuous variable is a composite of five questions from the parent questionnaire — father's education, mother's education, family income, father's occupation, and mother's occupation.)

High school student experiences

- High school STEM courses (this continuous variable represents the total number of Carnegie units of STEM courses a student took in high school. This includes all courses a student took in math, science, computer science, and engineering. A Carnegie unit represents 120 hours of class or contact time with an instructor over a one-year period.)

- High school exposure to AP STEM courses (two variables will be utilized to measure this. Sensitivity testing will be discussed later in this chapter as the method to determine to what extent the results are sensitive to the two different measures of AP STEM course-taking.)
    - Number of AP STEM courses (this continuous variable indicates the total number of Carnegie units of AP/IB STEM courses a student took in high school. This includes all AP/IB courses in math and science. While this variable includes IB (International Baccalaureate) courses as well as AP courses, there are only 900 participating high schools in the IB program in the United States compared with the more than 22,000 U.S. schools participating in AP (College Board, 2017; International Baccalaureate Organization, 2018). Thus, the number of IB courses only represents a small portion of the data collected for this variable, whereas the number of AP courses represents the majority of the data collected for this variable.)
    - Has taken any AP STEM courses (this dichotomous variable represents whether or not a student has taken any AP/IB STEM courses in high school. This includes any AP/IB courses in math or science.)
- Math self-efficacy (this composite continuous variable represents a student's math self-efficacy, with higher values representing higher math self-efficacy. This variable is a composite of four questions from the student questionnaire — confidence in taking math tests, understanding the math textbook, mastering math skills, doing well on math assignments.)

- Science self-efficacy (this composite continuous variable represents a student's science self-efficacy, with higher values representing higher science self-efficacy. This variable is a composite of four questions from the student questionnaire — confidence in taking science tests, understanding the science textbook, mastering science skills, doing well on science assignments. This variable has not been previously measured and is a new variable that has been included in HSLS:09 that was not measured in the previous NCES longitudinal studies.)
- High school math achievement (this continuous variable represents a student's college entrance exam (i.e., SAT, ACT) math section score standardized in terms of SAT.)
- Education aspirations (this categorical variable indicates whether high school students aspire to a graduate degree or higher. It is recoded as 1 for "yes" and 0 for "no".)

College student experiences

- Receipt of need-based financial aid (this categorical variable indicates whether a student was offered a Pell Grant during their first year of college. This variable will be recoded into a dichotomous variable with 1 for "yes" and 0 for "no.")

High school context

- School ID (this is a continuous variable representing the school identifier assigned for the base year sample high school. The use of fixed effects, discussed later in this chapter, will create a dummy variable for each school. However, the coefficient for each school will not be reported.)

Data Analysis

This study utilizes a two-level logistic regression model with fixed effects. In order to proceed with the inferential analysis methods, the variables have been recoded as described in the prior section. Additionally, I utilized multiple imputation to deal with missing cases that existed for some of the variables used in this study. Multiple imputation essentially predicts what the missing data values would be, filling them in by randomly drawing observations from the distribution (Allison, 2001; Schafer, 1999). Then, the researcher can perform analyses on the imputed dataset as if all of the data had been empirically observed. Multiple imputation can be applied to virtually any kind of data or model using conventional software (Allison, 2001). Multiple imputation has been widely accepted as an effective method for dealing with missing data in large data files from sample surveys, which makes it appropriate to use to in this study (Schafer, 1999).

Logistic Regression

A two-level logistic regression model with fixed effects was run to determine the relationship between AP STEM course-taking and STEM major selection, controlling for all relevant student-level and high school-level variables. Logistic regression is the appropriate form of regression analysis when the outcome variable is dichotomous, as is the case in my study (Peng, So, Stage, & St. John, 2002).

Since Stata software does not allow for including a weight variable in a logistic regression model with fixed effects, I also ran a linear probability model with fixed effects after the logistic regression model to determine whether incorporating a weight variable had any impact on the significance of the predictors to the model. A weight variable is necessary to include in a model to adjust for unequal probabilities of selection in the sample design and help ensure that the results of the analysis are representative the population (Thomas & Heck, 2001). While any oversampling at the school level in my sample was accounted for through the use of fixed effects, oversampling at the student-level could not be accounted for in this way. As Asian 9th grade students were oversampled in HSLS:09, it was important to determine whether inclusion of a weight variable would impact my results (Ingels et al., 2014).

Linear probability modeling, like logistic regression, is also appropriate to use when the dependent variable is binary, as it the case in my study (Caudill, 1988). The coefficients generated by a linear probability model represent the change in probability of the student selecting a STEM major for a one-unit change in the predictor variable of interest, holding all other predictors constant (Caudill, 1988). The main drawback of using linear probability modeling is that the model can produce probabilities outside of the acceptable range of 0-1 (Caudill, 1988).

My analysis also included a series of interaction effects tests, examining the variation of gender and racial/ethnic differences in STEM major selection as a function of AP STEM course-taking. The two sets of interaction terms are gender and AP STEM course-taking and race/ethnicity and AP STEM course-taking. Each set of interactions was incorporated into the baseline model independently. Each model with a set of interaction terms was then compared with the baseline model using a post-estimation test to determine whether either of these models represented a significant improvement over the model without the interaction effects.

Fixed effects. The option of conducting a randomized controlled trial whereby students are assigned to the treatment group or the control group was not feasible in this study. However, I needed to account for the fact that school-level factors are likely correlated with the probability of a student being in the treatment group (i.e., enrolling in an AP STEM course) as well as with the outcome (i.e., selecting a college STEM major). Therefore, in addition to controlling for student-level characteristics, I controlled for the school-level characteristics, which necessitated a two-level model to examine the data (Clark et al., 2010). Doing so accounted for the fact that students are nested within different educational institutions and may behave differently based on their different contexts (Hox, 2002; Clarke et al., 2010; Clarke et al., 2015; Huang, 2016).

In determining whether to treat the school-level factors as random or fixed effects, I first had to consider whether or not the regression assumption held in my study (Clarke et al., 2015). Random effects models assume that unobserved school-level characteristics are uncorrelated with other covariates. This is referred to as the regression assumption (Clarke et al., 2015). However, prior research indicates that clustering often occurs in educational studies looking at student outcomes across different schools because of the influence of unmeasured school characteristics such as teacher quality and school culture (Clarke et al., 2015). The students in my sample come from thousands of different high schools with different characteristics, some of which are not measurable. Thus, the regression assumption does not hold for my study, which indicates that the school-level factors should be treated as fixed effects. Fixed-effects models account for all effects of higher level variables, both observed and unobserved (Clark et al., 2010; Huang, 2016). By accounting for all variability associated with any school-level variables, the omitted variable bias is significantly reduced (Huang, 2016). Additionally, while it is difficult to draw causal inferences in observational studies, a fixed-effects model allows the researcher to draw inferences that are closer to causal than other methods, because the fixed-effect model accounts for the possible correlation of all higher level factors, observed and unobserved, with both the outcome and the treatment (Clark et al., 2015).

In order to determine whether a fixed effects approach is appropriate for my analysis, I need to decide whether I am interested in the effects of both level 1 (student) and level 2 (school) variables. A fixed-effects model does not allow for analysis of the influence of school-level factors. However, education methodologists support the use of fixed effects in a study when the researcher is only interested in the effect of level 1 variables, while controlling for second level observable and unobservable factors (Hahs-Vaughn, 2005; Huang, 2016; McCoach & Adelson, 2010; Thomas & Heck, 2001; Thomas, Heck, & Bauer, 2005). As the focus of my study is the influence of student-level (level 1) factors — specifically AP STEM course-taking, gender, and race — on the outcome, using a fixed-effects model is an appropriate method for my study. Therefore, I included the variables representing high school IDs as covariates in my regression model (Huang, 2016).

Sensitivity testing. Sensitivity testing is necessary in my analysis in order to determine which subset of variables accounts for more of the output variance, if any (Hussain, 2008). HSLS:09 includes more detailed data regarding high school student STEM experiences than earlier educational longitudinal studies. Therefore, I needed to run multiple models that incorporated different measures for the variable in my study measuring exposure to AP STEM courses in high school in order to determine which, if any, of the variables, have the most significant correlation to STEM major selection. Exposure to AP STEM courses is measured in HSLS:09 by whether or not a student took any AP STEM courses in high school was well as by the actual number of AP STEM courses a student took. Thus, sensitivity testing allows me to examine whether exposure versus number of courses matters in the model explaining STEM major selection. Thus, this study builds on earlier research, testing a two-level logistic regression model with fixed effects, using sensitivity testing to determine which high-school STEM exposure variables have the most significant relationship to STEM major selection.

Interaction effects. In order to examine the variation of gender and racial/ethnic differences in STEM major selection as a function of AP STEM course-taking, I also needed to run a series of interaction effects tests. Prior to running the interaction effect models, I generated interaction terms for the two variables, measuring exposure to AP STEM course-taking with gender and race/ethnicity. I ran the interaction effects tests using both a logistic regression and a linear probability model. After determining whether any of the interaction effects were significant to the model, I utilized Jaccard's (2001) method of generating predicted probabilities to more closely examine the interaction effect on STEM major selection.

Limitations

There are several limitations to this study that warrant discussion. First, the sample only includes students who declared a major by the time of the second follow-up survey. Therefore, students who declared majors later in their college career are not included in the sample.

Second, the study is constrained by data included in HSLS:09. Other factors that the literature has found to be related to STEM major selection and were measured in earlier NCES longitudinal studies, such as interaction with faculty and math and science readiness (Pascarella & Terenzini, 2005; Rosenbaum, 2001; Wang, 2013), are not included in the study as they are not measured in HSLS:09. Additionally, while HSLS:09 includes more STEM-specific data than past longitudinal studies, it is still lacking a high level of detail in the AP data collected. The total number of AP STEM courses – the key factor in this study – includes both AP and IB math and science courses taken. There is no variable in HSLS:09 that includes only AP math and science courses, and it leaves out AP computer science courses. Additionally, HSLS:09 does not specify what type of AP math or science course a student took (e.g., biology, physics, etc.), and as prior research indicates enrollment rates vary by race/ethnicity and gender across AP STEM courses, the specific math or science course could ultimately affect the results of the analysis. Furthermore, HSLS:09 does not include data on students' educational experiences prior to high school. Thus, student experiences in middle or elementary school that may contribute to STEM major selection are not controlled for.

Third, some sample members may have taken advanced, IB or non-AP STEM, coursework in high school, but I am not including the role of other advanced level coursework outside of AP in STEM major selection.

Another limitation that should be noted relates to the variable representing whether a student received need-based financial aid. While HSLS:09 collects data regarding a student's receipt of financial aid at a much more detailed level than prior longitudinal studies (indicating whether the source was federal, state, institutional, etc.), it does not categorize the aid as need-based or merit-based. For this study, I am using the variable that measures whether a student received a Pell grant to represent need-based aid, as this is the only financial aid variable that includes exclusively need-based aid. However, by only using this variable, I am not accounting for students in the sample who received other types need-based aid.

Finally, while understanding how students go about selecting a STEM major may be an important step in strengthening the STEM pipeline, selecting a STEM major does not necessarily mean a student will ultimately pursue a career in a STEM field.

Chapter IV: Results

Introduction

The results are presented in two sections in this chapter. The first section includes descriptive statistics of all variables in the model, including means. percentages, ranges, standard errors, and variance inflation factor (VIF) values. The descriptive statistics also include cross tabulations to compare characteristics of STEM and non-STEM majors as well as characteristics of students who have and have not taken AP STEM courses. A brief analysis of missing data in the sample is also included.

The second section of the chapter presents the results of the STEM college major model using a two-level logistic regression model with fixed effects. This section also includes the results of the sensitivity testing conducted to determine whether exposure to AP STEM courses versus number of AP STEM courses taken matters more in the model. Finally, my analysis includes a series of interaction effects tests, examining the variation of gender and racial/ethnic differences in STEM major selection as a function of AP STEM course-taking.

Descriptive Statistics

Tables 1 through 7 describe the independent variables in the model. All of the descriptive analyses were calculated prior to imputation. Tables 1 and 2 summarize descriptive statistics for all categorical and continuous variables in the model. Tables 3 and 4 present cross tabulations comparing characteristics of STEM and non-STEM majors. Table 5 summarizes statistics on whether or not a student took any AP STEM courses in high school, by gender and racial/ethnic group. Table 6 presents a similar summary by racial/ethnic group for the number of

AP STEM courses a student took in high school. Table 7 includes VIF values for all predictor variables.

As the descriptive statistics in Table 1 indicate, female students (55.72%) make up the majority of students in the sample. White students represent the largest ethnic group in the sample at 61.08%, with Hispanic students comprising 14.54%, black students 11.26%, Asian students 5.41% and students of Other races 7.72%. The demographic profile of the sample is similar to the demographic profile of the student higher education enrollment trends in the 2016 NCES Education Statistics Report (Snyder, de Brey, & Dillow, 2018).

Nearly 43% of the students in the sample have taken at least one AP STEM course. A majority of students (57.37%) aspire to earn a minimum of a graduate degree. Finally, more than half of the students in the sample (58.54%) are Pell grant recipients.

Table 1 Descriptive Statistics of Categorical Variables

Variable	Weighted Percentage	Standard Error	n*
Student Background Characteristics			
Gender			
Female	55.72%	0.01	7740
Male	44.28%	0.01	7740
Race/Ethnicity			
White	61.08%	0.01	7740
Black	11.26%	0.01	7740
Asian	5.41%	0.01	7740
Hispanic	14.54%	0.01	7740
Other	7.71%	0.01	7740
High School Student Experiences			
Has taken any AP STEM courses	42.70%	0.01	7740
Has not taken any AP STEM courses	57.30%	0.01	7740
Aspires to graduate degree or higher	57.37%	0.01	6880
Does not aspire to graduate degree or higher	42.63%	0.01	6880
College Student Experience			
Pell grant recipient	58.84%	0.01	5680
Not a Pell grant recipient	41.16%	0.01	5680

*All sample sizes in all tables have been rounded to the nearest 10 as per NCES data requirements.

Table 2 provides the weighted mean, standard error, and range of each continuous variable in the model – socioeconomic status, number of STEM courses, number of AP STEM courses, math self-efficacy, science self-efficacy, and Math SAT score. The mean socioeconomic status is 0.32. The mean number of STEM (AP and non-AP) courses a student took in high school (8.49) is approximately 11 times the mean of the number of AP STEM courses a student took in high school (0.77). The mean math self-efficacy score of 0.21 is slightly higher than the mean science self-efficacy score of 0.17. The mean Math SAT score of 536.51 is higher than the national mean Math SAT score of 514 for the Class of 2013 (the same cohort of students as my sample) reported by the College Board in its 2013 Profile Report for college bound seniors.

Table 2 Descriptive Statistics of Continuous Independent Variables

Variable	Weighted Mean	Standard Error	Min	Max	n*
Student Background Characteristics					
Socioeconomic Status	0.32	0.01	-1.75	2.15	7410
High School Student Experiences					
Number of STEM courses	8.49	0.04	0	20	7410
Number of AP STEM courses	0.77	0.02	0	9	7410
Math self-efficacy	0.21	0.02	-2.5	1.73	7210
Science self-efficacy	0.17	0.02	-2.47	1.64	7160
Math SAT score	536.51	2.27	200	800	4800

Tables 3 and 4 present descriptive statistics using cross-tabulation analysis to compare characteristics of STEM and non-STEM majors. As Table 4 indicates, the percent of male students who chose a STEM major is nearly twice the percent of female students who chose a STEM major, at 32.16% and 17.58%, respectively. At 41.06%, Asian students selected STEM majors at the highest rate of any racial/ethnic group, with black students selecting STEM majors at the lowest of any racial/ethnic group at 16.83%. Additionally, 24.71% of white students, 20.85% of Hispanic students, and 23.29% of students of Other races selected a STEM major. Of students who selected a STEM major, 66.11% took at least one AP STEM course, 29.36% aspired to a graduate degree or higher, and only 24.36% were Pell grant recipients.

Table 3 Cross Tabulation Analysis of Student Demographics and High School and Postsecondary Experiences by STEM and non-STEM Majors

Variable	Weighted Percentage	
	STEM major	**Non-STEM major**
Student Background Characteristics		
Gender		
Female	17.58%	82.42%
Male	32.16%	67.84%
Race/Ethnicity		
White	24.71%	75.29%
Black	16.83%	83.17%
Asian	41.06%	58.94%
Hispanic	20.85%	79.15%
Other	23.29%	76.71%
High School Student Experiences		
Has taken any AP STEM courses	66.11%	33.89%
Has not taken any AP STEM courses	16.69%	83.31%
Aspires to graduate degree or higher	29.37%	70.63%
Does not aspire to a graduate degree or higher	17.76%	82.24%
College Student Experience		
Pell grant recipient	24.36%	75.64%
Not a Pell grant recipient	25.66%	74.34%

As Table 4 shows, the mean socioeconomic status of students who selected a STEM major is 0.45, while the mean socioeconomic status of students who did not select a STEM major is 0.28. The mean number of STEM courses and AP STEM courses for STEM majors was 9.44 and 1.41, respectively. Both STEM major outcomes are higher than those for non-STEM majors, at 8.19 and 0.57. The mean math self-efficacy rating of 0.60 for STEM majors is 0.52 standard deviations higher the mean of 0.08 for non-STEM majors. Similarly, the mean science self-efficacy rating of 0.49 for STEM majors is 0.43 standard deviations higher than the mean of 0.06 for non-STEM majors. Finally, the mean Math SAT score for STEM majors is 589.44 compared to 518.76 for non-STEM majors.

Table 4 Cross Tabulation Analysis of Means of Academic Preparation Variables by STEM and non-STEM Majors

Variable	Weighted Mean	
	STEM major	**Non-STEM major**
Student Background Characteristics		
Socioeconomic Status	0.45	0.28
High School Student Experiences		
Number of STEM courses	9.44	8.19
Number of AP STEM courses	1.41	0.57
Math self-efficacy	0.60	0.08
Science self-efficacy	0.49	0.06
Math SAT score	589.44	518.76

Table 5 presents descriptive statistics using cross-tabulation analysis to compare characteristics of students who have taken at least one AP STEM course in high school to students who have not (the key factor in my study). While the majority of both female and male students have not taken any AP STEM courses, the percentages of each group having taken at least one AP STEM course are close at 42.35% of females and 43.15% of males. Asian students have the highest percentage of any racial/ethnic group with exposure to AP STEM courses in high school at 71.79%. The racial/ethnic group with the next highest percentage is Hispanic students at 43.78%, followed by white students at 41.79%, students of Other races at 41.43%, and black students at 33.16%.

Table 5 AP STEM Courses Taken (or not) in High School by Gender and Race/Ethnicity

Variable	Weighted Percentage	
	Has taken any AP STEM courses in high school	**Has NOT taken any AP STEM courses in high school**
Gender		
Female	42.35%	57.65%
Male	43.15%	56.85%
Race/ethnicity		
White	41.79%	58.21%
Black	33.16%	66.84%
Asian	71.79%	28.21%
Hispanic	43.78%	56.22%
Other	41.43%	58.57%

Table 6 presents descriptive statistics using cross-tabulation analysis to examine the mean number of AP STEM courses taken in high school across different gender and racial/ethnic groups. Male students, with a mean number of AP STEM courses of 0.84, have taken more AP STEM courses than female students, with a mean of 0.72. Asian students have taken the most AP STEM courses of any racial/ethnic group at 1.88, followed by white students at 0.75, students of Other races at 0.74, Hispanic students at 0.71, and black students at 0.45.

The results in Table 5 do not indicate a large disparity across racial/ethnic groups in AP STEM courses as the percentage of black students having taken at least one AP STEM course was only 8.63% lower than that of white students. However, Table 6 indicates a larger disparity when comparing the number of AP STEM courses taken as the mean for white students is nearly 67% greater than the mean for black students.

Table 6 Mean of AP STEM Courses Taken in High School by Gender and Race/Ethnicity

Variable	Weighted Mean	
	Total number of AP STEM courses taken in high school	Standard error
Gender		
Female	0.72	0.03
Male	0.84	0.02
Race/ethnicity		
White	0.75	0.02
Black	0.45	0.06
Asian	1.88	0.11
Hispanic	0.71	0.06
Other	0.74	0.07

The reported range of VIF (variance inflation factor) values in Table 7 is 1.03 to 3.90. As the range of VIF values for all variables in less than 10, none of the predictors are highly correlated (Allison, 1999). This indicates that a serious multicollinearity problem does not exist in my model.

Table 7 Variance Inflation Factor (VIF) Values for Independent Variables in Model

Variable	VIF
Student Background Characteristics	
Female	1.09
Black	1.12
Asian	1.20
Hispanic	1.10
Other race	1.05
Socioeconomic status	1.21
High School Student Experiences	
Has taken any AP STEM courses	2.44
Education aspirations	1.11
Number of STEM courses	1.25
Number of AP STEM courses	3.07
Math self-efficacy	1.19
Science self-efficacy	1.12
Math SAT score	1.74
College Student Experiences	
Pell grant recipient	1.07

Missing Data Analysis

Six of the 15 independent variables in the model have no missing data. Seven of the 15 independent variables have missing data ranging from 4%-11%. The variables representing Math SAT score and Pell grant recipient status have missing percentages of 38% and 27%, respectively. As discussed in Chapter Three, multiple imputation was used to deal with the missing data.

Two-Level Logistic Regression with Fixed Effects

In order to determine the relationship of student background characteristics, high school student experiences, and college student experiences, and the interactional effect of gender and race/ethnicity with AP STEM course-taking on the likelihood of selecting a STEM major, I ran a two-level logistic regression model with fixed effects. The odds ratio, significance level, and standard error for each variable in the model are included in Table 8. Odds ratios larger than 1 indicate a positive relationship of a variable with choice of STEM major, while odds ratios smaller than 1 indicate a negative relationship (Peng, So, Stage, & St. John, 2002).

The student background characteristics included in the model are gender, race/ethnicity, and socioeconomic status. A significant difference in the odds of selecting a STEM major exists between female and male students. The odds of a female student selecting a STEM major are 46% lower than the odds of a male student (OR = .54, $p<0.001$). The only racial/ethnic category significant in the model is Asian. The odds of an Asian student selecting a STEM major are 82% higher than the odds of a white student (OR=1.82, $p<0.001$). Socioeconomic status is not a significant predictor in the STEM major selection model.

The factors representing high school student experiences in the model include whether or not a student has taken any AP STEM courses, the number of STEM (AP and non-AP) courses taken, whether a student aspired to a graduate degree or higher, math self-efficacy rating, science self-efficacy rating, and Math SAT score. Every high school factor is a significant predictor in the model. For every additional STEM course a student takes, their odds of selecting a STEM major increase by 28% (OR=1.28, $p<0.001$). In looking at exposure to AP STEM courses — the key factor of the study — the odds of selecting a STEM major are 58% higher for students who take at least one AP STEM course in high school than for students who do not take any (OR=1.58, $p<0.001$). For every unit increase in math self-efficacy rating, the odds of a student selecting a STEM major increase by 37% (OR=1.37, $p<0.001$). With every one unit increase in science self-efficacy rating, the odds of a student selecting a STEM major increase by 23% (OR=1.23, $p<0.001$). Students who aspire to a graduate degree or higher have 30% higher odds of selecting a STEM major than students who do not (OR=1.30, $p<0.001$). Math SAT score is also statistically significant in the model. In order to make the interpretation more meaningful, I multiplied the coefficient by 10. Therefore, for every 10-point increase in SAT score, a student's odds of selecting a STEM major increase by 3% (OR=1.03, $p<0.001$). The variable representing a student's Pell grant recipient status, the college student-level variable, is found not significant in the model.

Table 8 Logistic Regression Analysis Predicting Choice of STEM Major (APSTEMANY)

Variable	Odds Ratio	Significance	Standard Error
Female	0.54	***	0.07
Black	1.19		0.14
Asian	1.82	***	0.10
Hispanic	1.15		0.12
Other race	1.09		0.12
Socioeconomic status	1.03		0.05
Number of STEM courses	1.28	***	0.02
Has taken any AP STEM courses	1.58	***	0.08
Math self-efficacy	1.37	***	0.04
Science self-efficacy	1.23	***	0.04
Aspires to a graduate degree or higher	1.30	***	0.08
Math SAT score	1.03 (per 10 points)	***	.0.0004
Pell grant recipient	1.05		0.08
Note: Significance: p<0.001***; p<0.01**; p<0.05*			

Sensitivity Test

After the logistic regression model was run once with the variable representing whether or not a student took any AP STEM courses, the logistic model was run a second time. In the second model, the variable representing whether a student took any AP STEM courses was replaced with the variable representing how many AP STEM courses a student took in order to determine whether either subset of variables accounted for more of the output variance (Hussain, 2008). The results of the second model are shown in Table 9. The resulting odds ratios and significance for the predictors in each model were similar. Both taking any AP STEM courses and number of AP STEM courses were positive predictors of STEM major selection. As mentioned previously, the odds of selecting a STEM major are 58% higher for students who took at least one AP STEM course in high school than for students who did not take any (OR=1.58, p<0.001). Similarly, for every additional AP STEM course a student took, their odds of selecting a STEM major increased by 31% (OR=1.31, p<0.001).

Table 9 Logistic Regression Analysis Predicting Choice of STEM Major (APSTEMCRED)

Variable	Odds Ratio	Significance	Standard Error
Female	0.53	***	0.07
Black	1.15		0.14
Asian	1.65	***	0.11
Hispanic	1.12		0.12
Other race	1.07		0.12
Socioeconomic status	1.02		0.05
Number of STEM courses	1.24	***	0.02
Number of AP STEM courses	1.31	***	0.04
Math self-efficacy	1.37	***	0.04
Science self-efficacy	1.24	***	0.04
Aspires to a graduate degree or higher	1.25	**	0.08
Math SAT score	1.02 (per 10 points)	***	0.0004
Pell grant recipient	1.05		0.08
Note: Significance: p<0.001***; p<0.01**; p<0.05*			

Linear Probability Model with Weight Variable

As discussed in Chapter 3, Stata software does not allow for including a weight variable in a logistic regression model with fixed effects. Tables 10 and 11 and present the results of the linear probability model with fixed effects that I ran after the logistic regression model in order to determine whether the findings from the analysis still stay the same in the sensitivity test when incorporating a weight variable in the linear probability model. The coefficients generated by the linear probability model in Tables 10 and 11 represent the change in probability of a student selecting a STEM major for a one-unit change in the predictor variable of interest, holding all other predictors constant (Caudill, 1988).

As the results displayed in Tables 10 and 11 indicate, the findings based on the linear probability model are very similar to the logistic regression model with regard to significance and hierarchy of the magnitude of the effect of each predictor on the outcome. The only exception, displayed in Table 11, is with the Asian predictor variable in the linear probability model that includes the continuous predictor representing how many AP STEM courses a student took in high school. In this model, the race/ethnicity category of Asian is no longer a significant predictor in the model. This can be explained by the fact that Asian students were oversampled in HSLS:09. Once weight was added to the model to account for the oversampling of Asian students, the higher likelihood of Asian students than white students selecting a STEM major is no longer significant.

Table 10 Linear Probability Model Analysis Predicting Choice of STEM Major (APSTEMANY)

Variable	Coefficient	Significance	Standard Error
Female	-0.09	***	0.02
Black	0.01		0.04
Asian	0.11	*	0.05
Hispanic	0.01		0.03
Other race	0.03		0.03
Socioeconomic status	-0.003		0.01
Number of STEM courses	0.05	***	0.005
Has taken any AP STEM courses	0.05	*	0.02
Math self-efficacy	0.05	***	0.01
Science self-efficacy	0.04	***	0.01
Education aspirations	0.05	**	0.02
Math SAT score	0.0004	***	0.0001
Pell grant recipient	-0.01		0.02
Note: Significance: p<0.001***; p<0.01**; p<0.05*			

Table 11 Linear Probability Model Analysis Predicting Choice of STEM Major (APSTEMCRED)

Variable	Coefficient	Significance	Standard Error
Female	-0.09	***	0.02
Black	0.01		0.04
Asian	0.09		0.05
Hispanic	0.004		0.03
Other race	0.03		0.03
Socioeconomic status	-0.01		0.01
Number of STEM courses	0.04	***	0.01
Number of AP STEM courses	0.06	***	0.01
Math self-efficacy	0.05	***	0.01
Science self-efficacy	0.04	***	0.01
Education aspirations	0.04	*	0.02
Math SAT score	0.0003	*	0.0001
Pell grant recipient	-0.01		0.02
Note: Significance: p<0.001***; p<0.01**; p<0.05*			

Interaction Effects

In order to examine the variation of gender and racial/ethnic differences in STEM major selection as a function of AP STEM course-taking, I ran a series of interaction effects tests. Prior to running the interaction effect models, I generated interaction terms for the two variables measuring exposure to AP STEM course-taking with gender and race/ethnicity. I ran the interaction effects tests using both a logistic regression and linear probability model, as I had done for all of my prior models. Tables 12 and 13 present each of the interaction terms along with the odds ratio/coefficient, significance, and standard error. It should be noted that the interaction effects tests in the linear probability model were not statistically significant, indicating that the relationship between AP STEM course-taking (in either measure) and STEM major choice was the same across males and females. The results based on the logistic regression analyses, however, show that inclusion of the interaction terms for gender and exposure to AP

STEM course-taking (when measured by number of courses and by whether any courses had been taken) generated significant improvement in the model at the 0.01 significance level. Thus, it can be concluded from the results of the interaction effects test using logistic regression that the relationship between AP STEM course-taking and STEM major selection varies significantly by gender. The results for the interaction of gender and number of AP STEM courses and gender (OR=1.15, p<0.01) and whether any AP STEM courses were taken (OR=1.53, p<0.01) both indicate that exposure to AP STEM courses tends to increase the odds of selecting a STEM major more significantly for female students than male students.

Table 12 Interaction Terms Tested for STEM Major Choice Model (APSTEMANY)

Variable	**Logistic Regression**			**Linear Probability Model**		
	Odds Ratio	Significance	Standard Error	Coeff.	Significance	Standard Error
Female*APSTEMANY	1.53	**	0.13	-0.005		0.03
Black*APSTEMANY	1.07		0.26	-0.12		0.07
Asian*APSTEMANY	0.98		0.21	0.05		0.08
Hispanic*APSTEMANY	1.29		0.22	0.0		0.05
Other race*APSTEMANY	1.05		0.23	0.06		0.06
Note: Significance: p<0.001***; p<0.01**; p<0.05*						

Table 13 Interaction Terms Tested for STEM Major Choice Model (APSTEMCRED)

Variable	**Logistic Regression**			**Linear Probability Model**		
	Odds Ratio	Significance	Standard Error	Coeff.	Significance	Standard Error
Female*APSTEMCRED	1.15	**	0.05	0.01		0.01
Black*APSTEMCRED	1.08		0.13	-0.02		0.04
Asian*APSTEMCRED	0.90		0.06	-0.005		0.02
Hispanic*APSTEMCRED	1.05		0.09	0.03		0.02
Other race*APSTEMCRED	1.04		0.09	0.02		0.03
Note: Significance: p<0.001***; p<0.01**; p<0.05*						

In order to more closely examine the interaction between gender and exposure to AP STEM courses, I utilized Jaccard's (2001) method of generating predicted probabilities. I calculated the predicted probability of STEM major selection for female and male students conditional on whether any AP STEM courses were taken while holding all other predictors at specified values (for dummy variables) or at their respective means (for continuous variables).

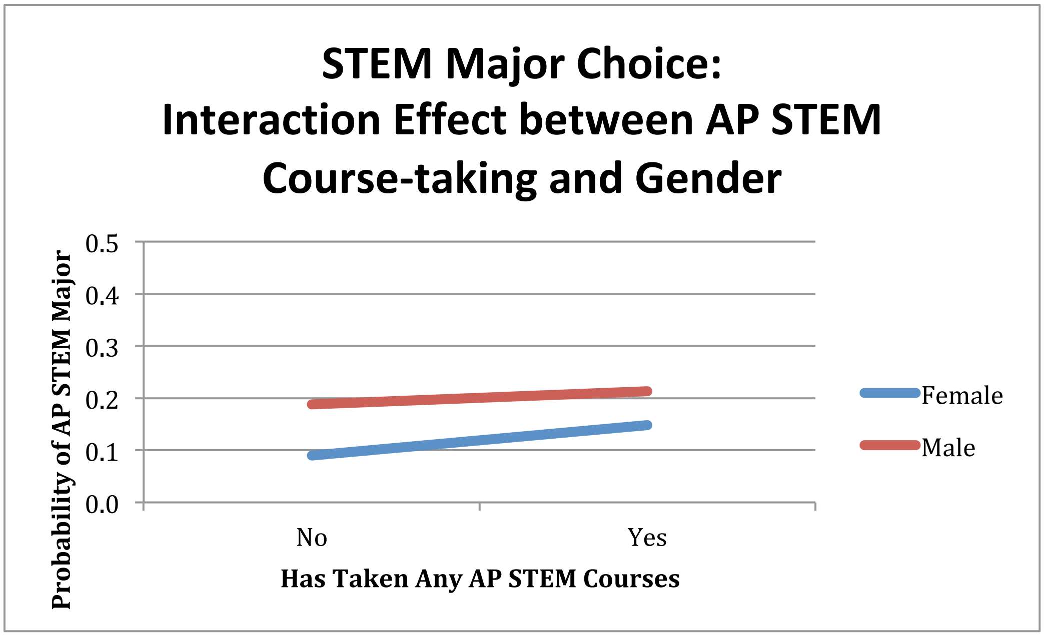
Table 14 presents the predicted probabilities of selecting a STEM major for male and female students who have and have not taken any AP STEM courses. The results indicate that among students who did not take any AP STEM courses, male students have a higher probability of selecting a STEM major. More specifically, controlling for all other predictors, male students have a probability of 0.1879 of selecting a STEM major while the probability for female students is 0.0898, representing a gender gap of 0.0981 probability points.

In order to examine to what extent AP STEM course-taking may be related to a narrower gender gap in STEM major selection, I estimated the difference in probability if a student took any AP STEM courses. The simulation results indicate that taking at least one AP STEM course is associated with a smaller gender gap in STEM major selection, as illustrated in Figure 1. The probability of selecting a STEM major for students who have taken at least one AP STEM course is 0.2127 for male students and 0.1480 for female students, narrowing the gap to 0.0647 probability points.

Table 14 Predicted Probability of STEM Major Selection by Gender Conditional on Having Taken Any AP STEM Courses

Variable	Female	Male
Has Not Taken Any AP STEM Courses	0.0898	0.1879
Has Taken Any AP STEM Courses	0.1480	0.2127

Figure 1 STEM Major Choice: Interaction Effect between AP STEM Course-taking and Gender



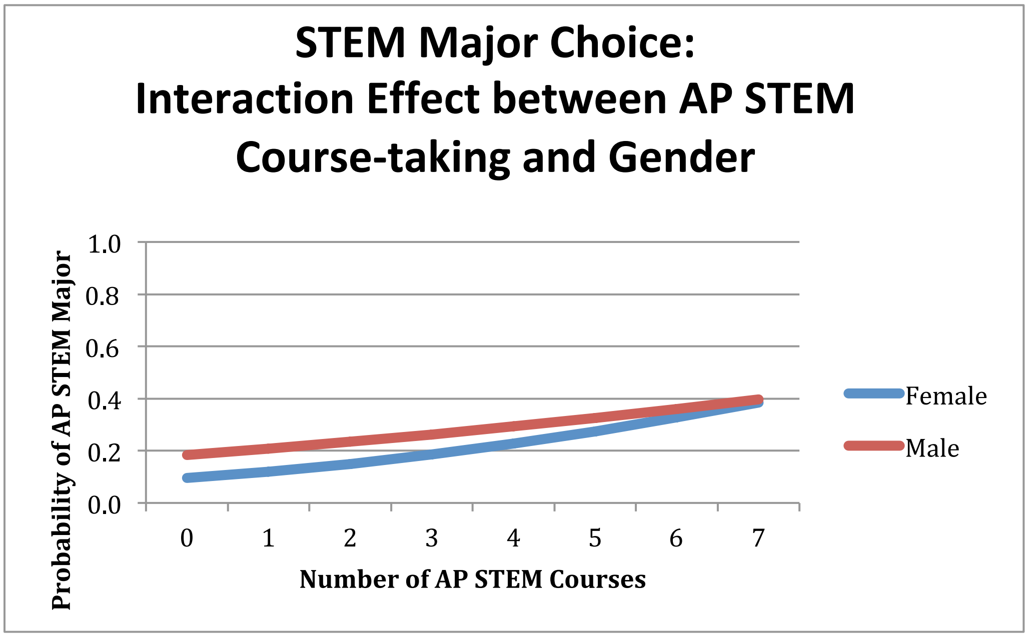
In order to further examine the effectiveness of the actual number of AP STEM courses in reducing the gender gap in STEM major selection, I repeated the probability calculation a second time, estimating differences in the probability of STEM major selection given different values of AP STEM courses taken. The results in Table 15 indicate that as the number of AP STEM courses taken increases, the gender gap is reduced. When no AP STEM courses have been taken, the probability of male students selecting a STEM major is 0.0879 probability points higher than for female students. When one AP course has been taken, the gender gap drops slightly to 0.0875 probability points. When two AP STEM courses have been taken, the difference drops to 0.0843 probability points. The gap continues to decrease for each additional AP STEM course taken, reaching a low of 0.0106 when seven AP STEM courses have been taken (the maximum number possible). The narrowing of the gender gap as the number of AP STEM courses taken increases is illustrated in Figure 2.

As the probability estimation model results in Tables 14 and 15 and Figures 1 and 2 clearly indicate, any exposure to AP STEM courses, as well as increasing the number of AP STEM courses taken, both narrow the gender gap in the probability of male and female students selecting a STEM major.

Table 15 Predicted Probability of STEM Major Selection by Gender Conditional on Number of AP STEM Courses Taken

Number of AP STEM Courses Taken	Female	Male
0	0.0958	0.1837
1	0.1202	0.2077
2	0.1497	0.2340
3	0.1850	0.2625
4	0.2265	0.2931
5	0.2740	0.3258
6	0.3274	0.3602
7	0.3856	0.3962

Figure 2 STEM Major Choice: Interaction Effect between Number of AP STEM Courses Taken and Gender



Chapter V: Conclusions and Implications

Introduction

The National Science Foundation (2018), President's Council of Advisors on Science and Technology (2012), and Bureau of Labor Statistics all project an increased need for STEM professionals in our nation over the next decade over and above what the United States will produce (NSF, 2018). In order to meet this demand and remain globally competitive in STEM fields, the United States must expand its STEM pipeline. Women and minorities are a currently underutilized source of human capital that could help fill the growing need in STEM fields (Bottia et al., 2015). In addition to tapping into this underutilized segment of our population, doing so will help diversify contributions in the STEM professions as well as provide opportunities for increased earning power of women and minorities.

One approach to expanding the STEM pipeline is to start early in students' academic careers by developing an understanding of what factors influence selection of a STEM major. In past studies, researchers have found that student background characteristics, high school experiences, including STEM course exposure, education aspirations, and early college experiences all contribute to college major selection (DeBoer, 1984; Ma, 2009; Moakler & Kim, 2014; Trusty, 2002; Wang, 2013). However, few studies have looked at the role AP STEM course-taking in high school may play in a student's selection of a STEM major in college, nor have they looked at how the impact may differ by racial/ethnic group and gender. As nearly 2.7 million students currently participate in the AP program in the United States, and the AP program has been linked to other college achievement indicators, including academic achievement and college completion, there is potential to use AP STEM course-taking as a means of expanding and diversifying the STEM pipeline if research shows a link between AP

STEM course-taking and subsequent pursuit of a STEM major (Klopfenstein, 2004; Malkus, 2016).

This study sought to develop a STEM major choice model, with AP STEM course-taking as the key factor, using a combination of Lent, Brown, and Hackett's (2000) social cognitive career theory and St. John, Asker, and Hu's (2001) social construct theory as the conceptual framework. This conceptual model incorporates both student-level and high school-level factors, and was used as the framework for the two-level logistic regression model using fixed effects in this study. This study was designed with the intent to help educators and policymakers shape college preparation programs and policies, as well as counsel students during their course selection process in high school. Additionally, identifying how the relationship of different AP pathways and college major selection varies by gender and race/ethnicity also informs decision-making to help equalize opportunity and representation of currently underrepresented groups in the Advanced Placement program and STEM fields. This study was guided by the following research questions: (1) After controlling for student background, high school experiences, and college experiences, how is AP STEM course-taking related to the likelihood of selecting a STEM major? (2) Does the relationship between AP STEM course-taking and STEM major selection differ by gender and race/ethnicity?

The sample for this study is taken from High School Longitudinal Study of 2009 and includes students who were high school freshmen in fall 2009. Data was collected on these students during fall of their freshman year of high school in 2009, during the spring of 11th grade in 2012, and in the spring of 2016, three years after the majority graduated from high school. This study utilized a two-level logistic regression model with fixed effects to determine the relationship between AP STEM course-taking and STEM major selection, controlling for all relevant student-level and school-level variables. Missing data was accounted for through multiple imputation. Sensitivity testing was also part of my analysis to examine whether exposure to AP STEM courses versus number of AP STEM courses matters in the model explaining STEM major selection. Lastly, my analysis also included a series of interaction effects tests, examining the variation of gender and racial/ethnic differences in STEM major selection as a function of AP STEM course-taking.

This chapter reviews the results presented in Chapter Four, followed by a discussion of implications for theory, policy, and practice. The chapter closes with recommendations for future research.

Summary of Findings

In seeking to answer the first research question, the results of the two-level logistic regression model with fixed effects found that a number of predictors in the model, including exposure to AP STEM course-taking, the key factor in this study, are significantly related to the likelihood of a student selecting a STEM major. In looking at student background characteristics, findings indicate that being female is linked to a decreased likelihood of selecting a STEM major. This is not surprising as it is in line with prior research findings on college major selection (Chen, 2009; Crisp et al., 2009; Mau, 2016). Contrary to some findings of prior literature, race is not significantly related to the likelihood of selecting a STEM major (Caputo, 2004; Chen, 2009; Ethington & Wolfle, 1988). In the logistic regression model without weights, being Asian significantly increases the likelihood of selecting a STEM major; however, this significance does not hold once oversampling of Asian students in HSLS:09 is accounted for in the linear probability model with weights. The final student background variable, socioeconomic status, is not a significant predictor of STEM major selection in my model, which does not add any clarity to prior literature findings that have been inconclusive regarding the effect of socioeconomic status on college major selection (Chen, 2009; Ethington & Wolfle, 1988; Ma, 2009).

All of the high school experience variables included in my model are significantly related to the likelihood of a student selecting a STEM major, including both measures of exposure to AP STEM course-taking. The number of AP STEM courses taken as well as taking at least one AP course are both positive predictors of STEM major selection, consistent with prior limited research findings (Dodd et al., 2002; Mattern et al., 2011; Morgan & Klaric, 2007). Additionally, while the effect is not as large as it was for AP STEM course exposure, the number of non-AP STEM courses taken, math and science self-efficacy, aspiring to a graduate degree or higher, and math SAT score all show a positive relationship with STEM major selection as aligned with similar results found in earlier studies (Chen, 2009; Hackett, 1985; Lee, 2015; Ma, 2009; Trusty, 2002; Wang, 2013; Ware & Lee, 1988) .

The only college student experience variable in the model, receipt of a Pell grant, is not a significant predictor of STEM major selection. Prior studies have found receipt of need-based financial aid to be a positive predictor of STEM major selection (Broton & Monaghan, 2018; Kienzl & Trent, 2009; Wang, 2013). Perhaps, if other types of need-based financial aid were included in my model and the variable was not limited to only Pell grants, the results for significance may have been different.

The second research question sought to examine whether the relationship between AP STEM course-taking and STEM major selection varies by gender and race/ethnicity. The results of the interaction effects test using logistic regression show that the relationship between AP STEM course-taking on STEM major selection varies significantly by gender. More specifically, exposure to AP STEM courses increases the odds of female students selecting a STEM major more significantly than for male students. Furthermore, calculated probabilities based on the logistic regression model indicate that increasing the number of AP STEM courses taken narrows the gender gap in the probability of male and female students selecting a STEM major.

It should be noted that, using linear probability modeling with weights as a sensitivity test, the interaction effect test for gender and AP STEM course-taking is not significant. Neither the logistic regression model nor the linear probability model shows any significant effect for the interaction between race/ethnicity and AP STEM course-taking.

Theoretical Implications

The conceptual framework used for the STEM major choice model in this study incorporates student background characteristics, high school experiences, college experiences, and school-level factors that have been linked to the likelihood of STEM major selection in prior literature as well as by Lent, Brown, and Hackett's (2000) social cognitive career theory and St. John, Asker, and Hu's (2001) social choice construct. Each of these factors points to a time along the continuum in a student's educational career when targeted interventions via policy or practice could be implemented to increase the flow of students into the STEM pipeline.

Both social cognitive career theory and social construct theory suggest that high school experiences, specifically the courses a student takes in high school, influence a student's future field of study and career choice. My findings add to the theoretical framework, showing that AP STEM courses are significant predictors of STEM major selection. Furthermore, neither social cognitive career theory nor social construct theory address differential effects of course-taking across gender, unlike my study. My findings suggest that the effects of AP STEM course-taking may be differentiated across genders.

My findings provide further support of both theories from which the conceptual framework for this study was developed as all of the other high school student-level variables included in the model are significant predictors of STEM major selection, including math and science self-efficacy, education aspirations, and Math SAT score.

Contrary to the proposed conceptual framework, neither race/ethnicity nor socioeconomic status is a significant predictor of STEM major selection. While the contradictory results of this study certainly do not disprove these components of the two theories, these findings may warrant further investigation as to why these background characteristics were not found to have a significant effect in this study.

While the conceptual framework included college level variables such as math and science readiness and interaction with faculty outside of class, in addition to receipt of financial aid, the first two factors were not measured in HSLS:09. Therefore, the only college level variable included in the study is related to receipt of financial aid. Pell grant recipient status was included as the financial aid variable. This factor is not significant in the model. However, this may indicate a need for a more comprehensive measure or additional variables, including whether or not the student was a recipient of other types of need-based aid, including a scholarship, grant, Stafford loan, or work study opportunity, in order to better represent the different types of financial aid a student may receive upon entrance to college.

Implications for Policy and Practice

Ensure access to STEM courses at all high schools

As the results of the study clearly indicate a link between exposure to AP STEM courses in high school and STEM major selection, expanding access to AP STEM courses for all high school students should be a priority of educators and policymakers. Research has shown that high school characteristics, including percent of students on free/reduced lunch, school size, and urbanicity, all are related to the likelihood of AP STEM courses being offered.

In Barnard-Brak, McGaha-Garnett, and Burley's (2011) examination of school characteristics and AP offerings using NELS:88 data, they found that schools with a lower percentage of students receiving free and reduced lunch were more likely to have a higher number of AP courses available to students. Virginia Public High School Fall 2012 Enrollment Data also revealed a negative correlation between the percentage of economically disadvantaged students in a high school and the availability of advanced math and science course offerings, including AP math and science courses (Ballard, 2018).

Analysis of state and national level data indicates that high schools with smaller enrollments are more likely to have fewer advanced/AP mathematics and science course offerings (Anderson & Chang, 2011; Monk & Haller, 1993; Robinson, 2003). An examination of Virginia public high school fall 2012 enrollment data showed that school size had a significant positive correlation to advanced math and science course offerings, including AP math and science offerings (Ballard, 2018). Similarly, data from the spring 2010 College Board report and U.S. Department of Education data indicated that 99% of large schools (more than 1,200 students) and 87% of medium size schools (500-1,199 students) have an AP Program compared with 44% of small schools (under 500 students) (Theokas & Saaris, 2013). The High School Transcript Study of 2005 results showed that while calculus is offered in 90.2% of large schools, it is only offered in 55.6% of small schools (Anderson & Chang, 2011).

Past empirical studies consistently show that rural students have significantly less access to advanced/AP math and science courses than students in more urban areas (Anderson &

Chang, 2011; Gagnon & Mattingly, 2015, McKinney, 2014). Analysis of 2005 HSTS data indicated that advanced math courses, especially AP Calculus and AP Statistics, were significantly less likely to be offered in rural schools than non-rural schools (Anderson & Chang, 2011). Similarly, Virginia public high school fall 2012 enrollment data revealed a statistically significant difference of advanced math and science course offerings, including AP math and science courses, based on urbanicity locale. Suburban public high schools offered significantly more advanced and AP math courses than city, town or rural schools. Urban schools offered significantly more advanced and AP science course offerings than suburban, town or rural schools (Ballard, 2018).

Fewer opportunities to take advanced/AP math and science courses in schools that are more economically disadvantaged, smaller in size, and more rural means that students in these schools do not have the same likelihood of selecting a STEM major in college as students who are afforded such opportunities in their schools (May & Chubin, 2003). Legislators and educational leaders at both the state and national levels should work to ensure that all students are provided with access to AP STEM courses. There are various means that can be utilized to achieve this parity. One method is by providing funding to help schools train teachers and develop curriculum. Additionally, partnerships can be facilitated for schools whose AP STEM offerings are lacking with other high schools and higher education institutions that can provide the courses via virtual learning means.

Eliminate artificial barriers to AP STEM course enrollment

While more than 22,000 high schools across the country participate in the AP program, consistent practices with regard to accessing these courses in these schools do not exist. The College Board outlines any necessary prerequisite courses for each of its AP offerings in its program guides; however, the College Board does not provide guidelines for schools to follow regarding other entrance requirements. Some high schools have lengthy application processes requiring minimum grades in prior courses as well as teacher recommendations, which can be very subjective, while other high schools offer open enrollment to AP courses. Educators should re-evaluate existing barriers to AP course entry, only keeping those that are necessary to ensure students have the appropriate prerequisite knowledge needed for the course. Schools may also look to establish summer bridge programs to help students prepare for the rigor of work required in an AP course. Summer bridge programs have been shown to effectively support students in preparation for academic success in high school (Hanover Research, 2017).

Promote AP STEM opportunities to female students

The interaction effect tests in the logistic regression results indicate that exposure to AP STEM courses increases the odds of female students selecting a STEM major more significantly than for male students. Therefore, while further analyses are needed to confirm my findings, school leaders and guidance counselors need to use this information to help guide female students and their parents in the course selection process.

According to the Extraordinary Women Engineers Project (2005), women seek a career that is relevant, rewarding, and impactful to society. Female students are often turned off by the messages sent from academia regarding the cutthroat, stressful world of STEM professions (Sinkele & Mupinga, 2011). Research has shown that all-girl STEM-focused workshops, such as summer camps and after school programs, that demonstrate to young women that careers in STEM can be fulfilling can stimulate interest among female students in pursuing STEM fields (Sinkele & Mupinga, 2011). Additionally, ensuring that female students have access to women in STEM fields as role models and resources (e.g., teachers, guest speakers) with whom they can relate and picture their own future through has also been shown to help spark interest among female students in STEM fields (Sinkele & Mupinga, 2011).

In addition to making sure both female students and their parents are aware of and understand the available STEM course offerings, counselors should be closely reviewing the College Board's AP Potential Report with their students, using it as a tool to inform students and their parents of a student's capacity to succeed in an AP STEM course. AP Potential (2012) is a free report that provides schools with rosters of students likely to score a 3 or higher on a given AP exam based on a student's PSAT or SAT score.

Outreach to female middle school students and their parents by high school faculty can also be an effective tool for igniting student interest in enrolling in STEM courses once they reach high school. STEM-themed family nights, curriculum information nights for parents, classroom visits for incoming students, and other collaborative endeavors showcasing opportunities have the potential of sparking conversation between teachers, parents, and students that can help set students on a path toward active enrollment in STEM courses.

Develop strategies to increase math and science self-efficacy of students

Findings indicate that math and science self-efficacy, as measured based upon a student's reported confidence in taking math tests, understanding the math textbook, mastering math skills, and doing well on math tests, are significant predictors of STEM major selection. Therefore, educators should be looking toward promoting math and science self-efficacy for high school students, and, perhaps, even for middle school students. Research has indicated that self-efficacy can be increased by using the right instructional strategies, such as helping students to set learning goals, providing timely and explicit feedback, encouraging students to study harder, and using high achieving students as models (Bandura, 1986; Bandura, 1997; Schunk, 1991; Siegle

& McCoach, 2007). Additionally, elimination of tracking (grouping students into different classes by academic ability) early in students' educational careers can also help increase math and science self-efficacy. Research indicates that otherwise-capable students placed into low math tracks have shown a decrease in their mathematics self-efficacy (Akos, Shoffner, and Ellis 2007; Callahan 2005).

Recommendations for Future Research

The findings of this study, along with prior research reviewed in Chapter Two, indicate that additional research is needed in order to find effective ways to expand the STEM pipeline and increase representation of women and minorities in STEM fields.

The results of the study indicate that exposure to AP STEM courses is a significant predictor of STEM major selection and is more significant for female students than male students. However, exposure to AP STEM courses was not found to be more significant for minorities than white students. This indicates that more work needs to be done in order to determine what other factors are associated with an increased likelihood of minority students selecting a STEM major and pursuing a STEM field, as the percentage of various racial/ethnic groups across STEM occupations has shown no increase since the early 2000's, with the exception of Asians (NSF, 2018). It would be worthwhile to examine interaction effects of race/ethnicity with the other high school experience variables included in the model in order to determine factors that may decrease the gap in STEM major selection between white students and minority students.

The focus of research should also be expanded to look at the combined differences in STEM major selection across both race/ethnicity and gender. Progress has been made in addressing the gender gap; however, female diversity has not been looked at as closely (Wang &

Degol, 2016). Black and Hispanic women are underrepresented in STEM fields, but studies often look at race and gender separately, overlooking the interaction of the two factors and the risk for additive discrimination that occurs when a person is part of two minority groups, often referred to as "double jeopardy" (King, 1992). Future studies should examine the interaction of race and gender in the decision to pursue STEM majors and STEM careers to inform policies that can effectively address the underrepresentation of racial minority females in STEM.

This study examined the factors related to selection of a STEM major. However, initially selecting a STEM major does not guarantee a student will earn a STEM degree and enter a STEM field. Future studies should examine actual completion of a STEM major/entrance into a STEM field as the outcome, looking at what factors may contribute to student retention/dropout of a STEM major prior to degree completion.

The results of this study also provide suggestions for future NCES data collection for research regarding STEM-related outcomes. While HSLS:09 includes more STEM-focused data than earlier NCES longitudinal studies, there are still other factors that literature has shown to be related to STEM major selection and entrance into STEM fields that were not measured in the survey. Some of these predictors include interaction with college faculty and math and science readiness upon college entrance (Pascarella & Terenzini, 2005; Rosenbaum, 2001; Wang, 2013). Additionally, HSLS:09 does not include data on students' educational experiences prior to high school. Thus, student experiences in middle or elementary school that may contribute to STEM major selection are not controlled for.

HSLS:09 also lacks a high level of detail in the AP data collected. Exposure to AP STEM courses – the key factor in this study – includes exposure to both AP and IB math and science courses when measured in HSLS:09. It does not include variables that measure only courses in

AP math and science, and it also leaves out AP computer science courses. Furthermore, HSLS:09 does not specify what type of AP math or science course a student took (e.g., biology, physics, etc.). As prior research indicates, enrollment rates vary by race/ethnicity and gender across AP STEM courses, and the specific math or science course could ultimately affect the results of the analysis (Ma & Liu, 2017). Additionally, the descriptive analysis for this study indicates a larger gap between black students and students of other racial/ethnic groups when looking at number of AP STEM courses taken instead of looking only at any exposure to AP STEM courses. Therefore, a greater level of detail in data collected on specific courses taken would be helpful in examining the racial/ethnic gap in STEM major selection.

The disparity across STEM subjects is also important to note as some STEM fields have higher earning potential than others. Students majoring in computer science and engineering have more earning power than physical science and biology majors (Cataldi, Siegel, Shepherd, & Cooney, 2014). Life sciences have a higher representation of females, while engineering fields have a lower female presence, thus, additional research is warranted that further examines the inequitable representation by gender and race/ethnicity across the different STEM subjects and fields (Ma & Liu, 2017).

Finally, some of the population sample may have taken advanced, non-AP STEM coursework in high school, which is not being accounted for as HSLS:09 data only distinguishes between all STEM courses and AP/IB STEM courses. The role of other advanced level coursework outside of AP in STEM major selection is not included in my study as it was not measured in HSLS:09.

The final area recommended for future research is in developing a method that can account for unobserved factors at the school level while also providing analysis on the impact of specific, observed school-level factors on the outcome. While this study accounted for school-level factors, the method and analysis focused on examining the effect of student-level characteristics. Looking at the impact of individual school-level factors, including programs offered, demographic composition, and policies and guidelines for AP course enrollment, is also important as educators and policymakers look to implement best practices and refine current policies and procedures in order to support expansion of the STEM pipeline. However, doing so is problematic with current methods and software. While propensity score matching allows for examination of higher level factors, it does not account for unobserved factors, nor can it be used with multiple imputation in Stata. Fixed effects, which was utilized in this study, accounts for higher level factors, but does not allow for examination of the influence of those factors on the outcome. Perhaps future studies can integrate propensity score matching and fixed effects, allowing for an analysis of observed factors while accounting for unobserved factors.

The United States must expand the STEM pipeline in order to meet the demand for a larger STEM workforce and maintain our nation's prosperity and competitiveness in the global economy. The urgency of this need has been proclaimed by policymakers, business leaders, politicians, and educators. Despite the growing demand for more STEM professionals, women and minorities are still an underutilized source of intellectual capital that can and should be tapped into. Doing so creates equity across genders and racial/ethnic groups as well as fosters inclusion of more diverse perspectives to enhance STEM innovations. Efforts to expand the number and diversity of those in STEM fields need to begin early on in students' academic careers. Educators and policymakers must seize the opportunity to implement targeted programs and practices, such as promoting access to AP STEM courses, in order to encourage and support students in pursuing paths to STEM-related careers — a crucial step in the expansion of the U.S.

STEM workforce. Doing so is imperative if the United States is going to remain competitive in an evolving global economy.

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Appendix A: Variables Used in STEM Major Choice Model

Table A1 Variables Used in STEM Major Choice Model

Variable Name	Description	HSLS Label	Time Collected
OUTCOME VARIABLE			
Selection of a STEM major (STEMMJR)	Respondent's major field of study is in STEM field; 1 = yes, 0 = no	X4RFDGMJSTEM	Second Follow-up 3 yrs after HS graduation - 2016
INDEPENDENT VARIABLES			
Student Background Characteristics			
Gender (female)	Respondent's gender; 1 = female, 0 = male	X2SEX categorical	First Follow-up Spring 11th grade
Race/ethnicity (White Black Asian Hispanic Other race)	Respondent's race/ethnicity; American Indian/Alaskan Native; Asian, Hawaiian/ Pacific Islander; African American; Hispanic, no race; Hispanic, race; more than one race, non-Hispanic; White	X2RACE categorical	First Follow-up Spring 11th grade
Socioeconomic status	This composite continuous variable was constructed based on father's education, mother's education, family income, father's occupation, mother's occupation	X2SES continuous	First Follow-up Spring 11th grade
High School Student Experiences			
Number of High school STEM courses	Units in STEM courses from high school transcript	X3TCREDSTEM	2013 Follow-up Summer after HS graduation

Variable Name	Description	HSLS Label	Time Collected
Number of High school AP STEM courses (APSTEMCRED)	Units in AP STEM courses from high school	Derived from X3TCREDAPMTH and X3TCREDAPSCI	2013 Follow-up Summer after HS graduation
Has taken any AP STEM courses (APSTEMANY)	Has taken any AP STEM courses in high school	Derived from APSTEMCRED	2013 Follow-up Summer after HS graduation
Math self-efficacy beliefs	This composite continuous variable was constructed based on responses to four questions from the student questionnaire - confidence in taking math tests, understanding the math textbook, mastering math skills, doing well on math assignments.	X2MTHEFF	First Follow-up Spring 11th grade
Science self-efficacy beliefs	This composite continuous variable was constructed based on responses to four questions from the student questionnaire - confidence in taking science tests, understanding the science textbook, mastering science skills, doing well on science assignments.	X2SCIEFF	First Follow-up Spring 11th grade

Variable Name	Description	HSLS Label	Time Collected
High school math achievement	This continuous variable represents a student's college entrance exam (i.e., SAT, ACT) math section score standardized in terms of SAT).	X3TXSATMATH	2013 Follow-up Summer after HS graduation
Education aspirations (GRADASP)	Whether respondent aspires to graduate degree or higher; 1 = yes, 0 = no	S2EDUEXP	First Follow-up Spring 11th grade
College Student Experiences			
Receipt of need-based financial aid (PELL)	Offered Pell grant during first year of college; 1 = yes, 0 = no	S3CLGPELL	Second Follow-up 3 yrs after HS graduation - 2016 (measures if Pell grant offered for 2013-2014 school year)
High School Context			
School ID	School identifier assigned for the base year sample high school	SCH_ID	Base Year Fall 9th grade