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Exploring Community Colleges in the Stem Education Landscape : development of stem college major choice model

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EXPLORING COMMUNITY COLLEGES
IN THE STEM EDUCATION LANDSCAPE:
DEVELOPMENT OF STEM COLLEGE MAJOR CHOICE MODEL

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Abstract

Community colleges are becoming increasingly relevant as an entrance point into postsecondary education for potential science, technology, engineering, and mathematics (STEM) majors. These institutions are also an important education pathway for women and racial/ethnic minorities who are currently underrepresented in the STEM workforce. The purpose of this study is to understand how student demographics, high school, and college experiences influence the entrance of community college students to the STEM college majors. Data from the Education Longitudinal Study of 2002 (ELS: 2002) were used for the study. Students included in the study began their postsecondary education at community colleges. Descriptive and binary logistic regression analyses were performed to examine the impact of student demographics, high school, and college experience on the choice of STEM college major. The findings of this study suggest gender, race/ethnicity, academic preparation, and interest in STEM fields upon entering college influence the choice of STEM major by community college students.

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DEDICATION

To my husband, Tarek,

for his unconditional support and inspiring example of excellence.

To my children, Bayan and Rayah, for their patience and encouragement.

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Chapter I: Introduction

Government, business, and scientific leaders have sounded the alarm for an impending category 5 storm, which will compromise America's readiness to compete in the 21st century global economy (National Academy of Science, 2010). Global economic leadership is tied very closely with the nation's strength in the areas of science, technology, engineering, and mathematics (STEM). In the last half of the 20th century, America's economic leadership stemmed in part from technological advances and discoveries made by its STEM workforce. While the STEM workforce comprises 5% of the total American workforce, it has been responsible for more than half of the sustained economic growth in the last fifty years (Babco, 2007). Our nation's long-term economic health will depend in part on the enhancement of the supply and quality of the STEM workforce.

The Department of Commerce estimates that the STEM workforce will grow 1.7 times faster than the non-STEM workforce between 2008 and 2018 (The Department of Commerce, 2012). To meet the projected workforce needs, the current Obama administration has put forth a goal of increasing the number of students receiving undergraduate STEM degrees by one million over the next decade (President's Council of Advisors on Science and Technology, 2012; White House, 2012). As part of an integrated approach to achieve these one million graduates, community colleges are highlighted as potential pathways for students to achieve STEM degrees (White House, 2012).

The role of 2-year postsecondary institutions commonly referred to as community colleges in the education of STEM majors is increasingly becoming an important pathway to STEM degrees (Horn, Neville, & Griffith, 2006). The influence of these institutions on the nation's STEM education pipeline is highlighted in a report based on the National Science Foundation (NSF) 2001 National Survey of Recent College Graduates (NSRCG), which found on average that 44% of science and engineering graduates attended a community college. While the NSRCG survey data does not distinguish between intensity and timing of attendance by students, it clearly substantiates the assertion that community colleges will have considerable future influence on the landscape of STEM education. The importance of community colleges in the STEM education pipeline is further supported by a study using 1996/01 Beginning Postsecondary Students Longitudinal Study as the data source. Of those students who initially declare STEM majors in this study, 39.8 % attended community colleges. Important trends noted in this study include the predominance of Bachelor degree level students (> 50%) and mathematics, engineering, and computer/information science majors (50%) among students attending these institutions. To a lesser extent, students at higher degree levels and other types of STEM majors begin their postsecondary education at community colleges. One third of master degree and 8% of doctorate degree recipients, and approximately 25% of natural sciences, biological sciences, and physical sciences majors attended a 2-year institution as their first institution (Chen & Weko, 2009; Tsapogas, 2004). These trends aid in positioning community colleges as an important pathway for students to prepare to enter the STEM workforce.

The composition of the STEM workforce is influenced by two key demographic parameters: gender and changing racial/ethnic demographics. The current retirement of the baby boomer generation from the STEM workforce, which has been traditionally dominated by white males, is creating a void in the STEM workforce. In order to fill this void, our future STEM workforce will need to mirror and embrace the changing population demographics. Participation of racial/ethnic minority groups as well as women who have long been underrepresented in certain sectors of the STEM workforce will be critical to create a competitive future STEM workforce (Babco, 2007; IBM Corporation, 2008; Science and Engineering Indicators 2006; United States Department of Labor, Employment and Training Administration, 2007).

Of the minority groups increasing in numbers in the US, Hispanic citizens are predicted to experience the largest increase (33%) of all groups by 2018 (United States Department of Labor, 2010). African Americans are expected to double their population by the middle of the 21st century while the white non-Hispanic part of population which has been the traditional source of the majority of STEM professionals will continue to decline steadily from 73% of the population in 1995 to 53% of the population in 2050, a decrease of almost 30% (Day, 1996).

Currently, African Americans, Hispanics, and American Indians/Alaskan Natives combined are proportionally underrepresented in science and engineering occupations compared to their presence in the general population in the United States. These racial/ethnic minority groups constitute 24% of the general population and 10% of the science and engineering workforce. In contrast, Asian/Pacific Islanders minorities, which

represent 5% of the population, hold 14% of science and engineering jobs. The presence of African Americans and Hispanics in the science and engineering workforce has doubled in the past three decades. Despite these modest improvements, the presence of African American and Hispanics in the STEM workforce is still unacceptable at 5% and 4% respectively in 2010 (National Science Board, 2010). Likewise, women have increased their presence in the science and engineering workforce from 12% in 1980 to 27% in 2007. Despite this positive trend for women, they are still opting out of joining the STEM workforce. Explanations for underrepresentation of women in the workforce include a lack of female role models and less family friendly flexible work conditions (Beede et al., 2011). These demographic trends highlight the importance of access of ethnic and racial minorities to the highest quality STEM education so they will be present in the STEM talent reservoir. The convergence of adequate numbers of qualified students traveling through the STEM education pipeline and the projected demographic trends of the American population over the next 50 years are singled out as influential parameters, which will affect the reservoir of potential STEM professionals (Business-higher education forum, 2010; Museus et al., 2011; United States Department of Labor, Employment and Training Administration, 2007).

The challenge of increasing the presence of underrepresented minorities and women in STEM careers opens the doors for community colleges to play an important role in the education of racial/ethnic minorities and women as they enter postsecondary education. As of 2008, more than half of Hispanics, 44% of African Americans and 58% of women attended community colleges as their first postsecondary institution. STEM degree recipients mirror the same community college attendance trends reported. Over

60% of Hispanic STEM majors reported attending community colleges at some point during their postsecondary education. Similar trends are noted among other minorities with 45% of African American and 40% of Asian/Pacific Islanders having attended community college before receiving their baccalaureate or Master's degree (Tsapogas, 2004; Malcolm, 2010).

One avenue to address the gaps in the STEM workforce resulting from demographic parameters can be accomplished by refocusing efforts on the STEM education pipeline (National Science Foundation, 2007). These demographic trends highlight the importance of access of ethnic and racial minorities to the highest quality STEM education so they will be present in the STEM talent reservoir. Increasing the presence of academically prepared racial/ethnic minorities and women in the STEM education pipeline with the necessary support systems will be one part of an integrated approach to meet the nation's future STEM workforce demands (National Academy of Science, 2010). The STEM education pipeline refers to the education pathway students follow through primary, secondary, postsecondary, and graduate levels to eventual STEM careers. In order to proceed successfully through the pipeline, students must maintain interest and motivation in the STEM fields, develop necessary academic skills, and find sufficient support systems to facilitate movement to the next level (Clotfelter, 2010; Museus, Palmer, Davis& Maramba, 2011).

While there are many points where students pass in or out of the STEM education pipeline, one important decision-making milestone for postsecondary students is the choice of academic major. The choice of academic major has important implications for

future careers and merits more study to expand the current theoretical models (Lackland & De Lisi, 2001). Understanding why students enter STEM fields will help educators and education policymakers facilitate and support students' entrance and movement through the STEM education pipeline.

Much research efforts have concentrated to this point on (a) K-12 STEM preparation; (b) persistence/ retention in STEM programs; (c) degree completion by STEM majors. On the other hand, fewer efforts have concentrated on understanding why students enter the STEM fields (Anderson & Dongbin, 2006). Further, the majority of research effort focusing on college major choice either involves students who attend 4-year colleges and universities or have merged 2-year and 4-year college students into one group. Currently, there is a gap in the literature concerning STEM majors, who begin their postsecondary education at 2-year institutions.

Research on choice of STEM college major has emphasized the study of parameters such as student demographic characteristics and experiences in middle school, high school, and the first year of postsecondary education as important determinants in the choice of STEM major. Middle school, high school, and early college years are major points in the STEM education circuit where students can transfer in or out of STEM education. The term STEM education circuit is used instead of the more commonly term STEM pipeline to represent the multiple and varying pathways students employ in their journey toward completion of terminal STEM degrees (Museus et al., 2011). Researchers have found high school parameters such as interest in STEM, mathematic proficiency, math self-efficacy (Betz & Hackett, 1983), academic performance and STEM course taking patterns (Trusty, 2002) influence the choice of STEM major in

postsecondary education. Racial differences in mathematics proficiency are evident early on with fewer African American and Hispanic students performing at a proficient or higher level than their white and Asian counterparts (National Center for Education Statistics, 2009). A steady decline in interest in STEM fields as students pass from middle school to high school into college affects the number of potential STEM majors in college. As students leave their middle school years, according to American College Testing (ACT) data, only one-third of 8th graders are interested in STEM as they transition into high school (Business-Higher Education Forum, 2010). The pool of potential STEM college majors narrows further by the end of high school. By the time students reach 12th grade, only 17.3% of 12th graders are both proficient in mathematics and interested in STEM fields based on ACT data (Business-Higher Education Forum, 2010).

While most research studies on college major choice have emphasized demographic characteristics and high school experiences, the first two years of college are also influential in the decision-making process as students often begin exploring different majors during their first years of college. In general, 30% of students change their majors during the first year (Clotfelter, 2010). As the students who are academically prepared and interested in STEM enter 4- year institutions, there is a substantial number who transition out of the STEM circuit into non-STEM majors. From a study (Clotfelter, 2010) using a sample restricted to full-time, traditional age students attending a 4-year institution with an expressed interest in STEM major upon entering college, 43% actually declared a STEM major. When restricting the sample further to students who have an interest in STEM and are academically prepared with ACT scores

of 25 or greater in math and science, and a high school math grade point average (GPA) of 3.5 or greater, only 50-54 percent of students remained as STEM majors. In response to when the defections from STEM majors are most likely to occur, the very first semester at college is important in determining how committed a student is to staying in the STEM education circuit (Clotfelter, 2010).

When students enter college with an interest in majoring in STEM fields, it is important that support systems are in place to facilitate student progress in the college major decision-making process. External supports which assist in successful transitioning into college can come in the form of academic integration which may be facilitated by positive interactions with faculty and advisors (Adelman, 1999; Kim, 2010; Wang, 2013). With increasing college costs and time to STEM degree completion, students are struggling to finance their way through the STEM education circuit. Current changes in the type of financial aid available can affect their decision to major in STEM fields and hinder their progress to a terminal degree (Slater, 2011).

The emergence of community colleges as an accessible pathway for students who pursue STEM degrees necessitates increased research effort to better develop effective education policy and practice. Since the majority of empirical research in college major choice research has focused on 4-year colleges and universities, studies that target community colleges will increase understanding of the parameters influencing this segment of students who enter postsecondary education for the first time. Further, given the important role community colleges play in the education of racial and ethnic minorities and women, more effort is needed to increase the success of these students as they pursue STEM degrees (Freedman, 2011; Malcolm, 2010; Museus et al., 2011).

Overview of This Study

This study will develop a model of STEM major choice to help educators, administrators, and education policymakers understand how high school and college experiences influence the choice of STEM major by community college students. This model will incorporate student demographics and high school and college experiences, which are documented in the literature as important factors in determining the choice of STEM college major. In choosing to focus on students who begin their postsecondary education at community colleges, this study hopes to examine a population of students who are missing from college major choice literature and are underutilized as a source of potential STEM majors. This study also seeks to highlight the differences in experiences of women/men and racial/ethnic minorities attending community colleges and their impact on choice of STEM college major. With these objectives in mind, the following research questions will guide the inquiry:

1) How do high school experiences such as math self-efficacy, math achievement, interest in STEM, and exposure to math and science influence the choice of STEM major by community college students?

2) How do college experiences such as interactions with faculty/advisor, receipt of financial aid, degree aspiration, and perceived college readiness in math and science influence the choice of STEM major by community college students?

3) Do these effects of high school and college experiences on STEM major choice vary by gender and race/ethnicity among community college students?

This study will develop a model of STEM major choice using the social cognitive career theory (SCCT) as the conceptual framework (Lent et al., 1994; Lent, et al., 2003; McInerney, Didonato, Giagnacova, & O'Donnell, 2006; Nauta & Epperson, 2003). SCCT as a conceptual framework is particularly relevant to this study since the theoretical constructs included are self-efficacy, learning experiences, interest, outcome expectations, and environmental supports. Further, the sample for this study will be derived from Education Longitudinal Study of 2002 (ELS: 2002) which is one of the most recent national studies following a cohort of students from their sophomore year in 2002 through their first two years of postsecondary education in 2006. This study will focus on the period from senior year in high school through the second year of postsecondary education. The sample used in this study will include students who were high school seniors in spring 2004, participated in the second follow-up survey while attending a 2-year institution as their first postsecondary institution and declaring a major by 2006.

Significance of the Research

By focusing on students who begin their postsecondary education at community colleges, this study will provide insights into an important population of postsecondary students who contribute to the reservoir of STEM students in today's higher education system. There is a void in the STEM college major literature regarding community college students and their path to success in the STEM education pipeline. This study will examine the college major decision point in the STEM education pipeline. According to the conference report "Community Colleges in the Evolving STEM Education Landscape", some of the greatest challenges identified by leaders from

community colleges and researchers with expertise in community colleges were: (a) overcoming inadequate preparation in mathematics, sciences and critical thinking of students entering postsecondary education; (b) recruiting students into the STEM education pipeline; (c) supporting them on their academic journey (Olson & Labov, 2012). These concerns were especially linked to women and minorities interested in STEM careers. This study will develop a college major choice model, which will include parameters of math self-efficacy, academic preparation, interest in STEM, education aspiration and environmental supports during community college attendance. Insights gained from the development of this model will assist high school administrators and teachers to design and implement better curriculum and policy that will inspire and academically prepare these students to successfully traverse the STEM education pipeline. By inclusion of college parameters such as student/faculty experiences and financial aid which might support potential STEM majors, insights into the role of faculty/advisors and financial support may prove helpful to STEM departments and campus financial aid officers. Parameters such degree aspiration and perceived college readiness in the proposed model will address the role of motivational issues and perception of the degree of alignment of math and science high school coursework with college level course requirements in the choice of STEM major.

In order to further research college major choice literature, this study will test the usefulness of social cognitive career theory (SCCT) as a theoretical framework (Ma, 2009; Turner & Bowen, 1999; Nutting, 2008). The SCCT theory has been used as the theoretical basis for career choices but has been underutilized specifically in the study of STEM fields (Brown, 2002; Lent et al., 1994; Lent, et al., 2003). The addition of

postsecondary support systems, which are available in SCCT, will enable the researcher to connect high school and college experiences into one cohesive model. This will enable policymakers to begin to view the STEM education pipeline from a K-16 perspective. Development of a model to understand why students enter the STEM fields will help educators and education policymakers better meet the needs of potential STEM students.

Finally, this study also addresses recommendations made by the National Academy of Science, National Academy of Engineers, and Institute of Medicine to enhance America's ability to compete in today's global economy. Improving math/science education quality and accessibility of minority students to STEM education are two recommendations related to the STEM education important in ensuring a productive and viable STEM workforce in the United States (National Academy of Science, 2010).

Organization of the Dissertation

After the introduction in Chapter One, a comprehensive review of the current literature in Chapter Two discusses theories utilized as conceptual frameworks and relevant parameters that influence STEM college major choice, followed by a summary and critique of the literature. Based on the review of the literature, a theoretical framework and methodology for the present study is proposed. Chapter Three presents the research design of the study. This section will include the data source, sample, and research methods. Chapter Four reports the findings of data analysis, which are guided by the research questions. Finally, Chapter Five discusses conclusions, implications for research, practice, and policy, and suggestions for future research.

Chapter II: Literature Review

The choice of college major is a pivotal moment in career development and vocation choices (Lackland & De Lisi, 2001). Although extensive research has been conducted on retention, persistence, and degree completion in the STEM fields (Brainard & Carlin, 1998; Daempfle, 2003/2004; Seymour & Hewitt, 1997; Scott, Tolson, & Huang, 2009), research on selection of college major by students who are entering the STEM fields is not as well developed. Studies on students entering college often use the choice of college major as a source of measurable educational outcome. The education pathway leading up to the commitment to a STEM major begins early in the STEM education circuit with critical junctures beginning as early as middle and secondary school. The transition between secondary and postsecondary education is one point where there is a greatest loss of potential STEM majors. Even academically qualified students are choosing not to major in the STEM fields before they enter or when they enroll in college (Clotfelter, 2010; Lee, 2002). Attrition rates from science and engineering majors are similar for men and women during postsecondary education; however, real differences are seen in the rates of matriculation for men, women, and minorities into the STEM fields (Leslie, McClure, & Oaxaca, 1998). Before the actual choice of STEM major occurs, many factors such as gender, socioeconomic status, race/ethnicity, interest in STEM, pre-college academic preparation (Crisp, Nora, & Taggart, 2009) and college experiences, such as financial aid, academic integration and education aspiration affect a student's decision to major in the STEM fields (Slater, 2011; Wang, 2013). Often these factors vary in impact along gender and racial/ethnic lines which make the understanding

of how these factors affect the choice of STEM majors so critical (Anderson & Dongbin, 2006; Cole & Espinoza, 2008; Simpson, 2001).

This literature review presents a critical analysis of the current state of research and theory in the area of choice of STEM college majors. The purposes of this literature review are (a) to critically review theoretical frameworks used to guide research in college major choice research; (b) to identify factors which have been reported in existing literature to influence the choice of academic major with particular emphasis on STEM majors; (c) to examine weaknesses and strengths of research on college major research studies; (d) to discuss data sources used in published studies; (e) to propose a model which uses an appropriate theoretical frame to predict choice of STEM major in second year community college students.

I will include empirical studies dealing with the influence of student demographics (gender, race, and socioeconomic status), high school academic preparation, STEM interest, interactions with faculty/advisors, receipt of financial aid, education aspiration, and perceived college readiness in math and science on the choice of STEM as an academic college major in this review. Scholarly books and peer-reviewed journal articles were found through electronic searches using educational databases (ERIC, Proquest, and Dissertation Abstracts) and web-based search engine, Google Scholar.

Theoretical Framework for Choice of College Major Research

The theoretical frameworks guiding research in college major choice studies draw on career choice theories as a result of the connection between college majors and eventual career choice. The Holland's career development theory (Holland, 1997), Krumboltz's social learning theory of career decision making (Krumboltz, 1979), and Lent, Brown, and Hackett's social cognitive career theory (Lent & Brown, 1996) are important career development theories emphasized in college major choice studies. Career development theories are often used in studies on college major since the choice of major is an important step students take on their path to a future career. The choice of major is particularly important in the STEM fields given that there are very specific education requirements for many of the STEM careers. I will review and analyze each of these theories in details as follows.

Career development theories

Holland's career development theory. Holland's career development theory (Holland, 1959), which was first proposed in 1959, has focused on the relationship of an individual's personality or behavior style and choice of vocation. Holland's theory has stimulated substantial research activity since its development and remains one of the most popular career development theories (Patton & McMahon, 2006). The basic premise of the theory is that individuals seek congruence between their personality and work environment. This action is one of the driving forces in determining their choice of career or vocation. In Holland's theory the environment can refer to the work or career environment or college major as is the case in the studies in this review. Personalities

and environments are characterized using Holland's categories of realistic (R), investigative (I), artistic (A), social (S), enterprising (E), and conventional (C) (Brown, 2002; Porter & Umbach, 2006). For example, investigative (I) college majors include biology, mathematics, and engineering, and enterprising (E) majors include business and computer science. Although Holland's theory holds an important place in the career development literature, only one study in the literature integrated personality as part of a college major choice model. The personality type scales were constructed from the responses of incoming freshmen in the Cooperative Institutional Research Program (CIRP) Students Information survey. Construction of personality-type scales from survey questions instead of using personality assessment instruments proved to be a limitation in the case of the investigative personality scale due to low reliability (Porter & Umbach, 2006). Several other studies used the Holland characterization of different college majors as realistic (R), investigative (I), artistic (A), social (S), enterprising (E), and conventional (C) in combination with Krumbolz's social learning theory to study the effect of learning environments on college major choice (Brown, 2002; Porter & Umbach, 2006; Trusty, 2002; Trusty & Ng, 2000; Trusty, Ng, & Plata, 2000).

Krumbolz's social learning theory. Krumbolz's social learning theory of career decision (Krumboltz, 1979) is related to Holland's theory in that it also places importance on the fit of the individual with their environment. Interaction of individuals and their environment influence educational and occupational choices. An individual's environment includes learning experiences, which can occur informally at any time or formally in the classroom. These learning experiences bring about self-observation (perception of performance in specific areas) and task approach skills (coping,

interpreting, adapting to environment), which in turn influence educational choice actions like choice of college major (Krumboltz, 1979). Although Krumboltz's social learning theory has not stimulated the same level of research activity recently as Holland's theory and the social cognitive career theory (Brown, 2002), studies of high school and middle school academic experience have utilized this theory as its conceptual framework when examining the learning environment of students and its impact on choice of college major (Trusty, 2002; Trusty, Robinson, Plata, & Ng, 2000). The middle school learning experiences focused on the impact of 8th grade academic performance in reading and mathematics cognitive tests and high school experiences such as course taking patterns in mathematics and science, grade point average, and SAT scores on STEM major choice.

Social Cognitive Career Theory. The social cognitive career theory (SCCT) derives its theoretical basis from the social cognitive theory (Bandura, 1989, Lent & Brown, 1996). SCCT, which is utilized in the study of both academic and career behavior, borrows the three social cognitive constructs of self-efficacy, outcome expectations, and goals parameters from Bandura's social cognitive theory (Lent et al., 1994; Bandura & Adams, 1977; Lent, et al., 2003.) The SCCT model has been further refined and expanded to include learning experiences, interest, and environmental supports and barriers. All of these parameters can potentially influence career or academic related choices like academic major in college (Lent et al., 2003). Many studies examining the relationship between STEM major choice and academic or mathematics self-efficacy, interest, and math/science ability have generated research in support of the utility of this theory (Betz & Hackett, 1983; Leslie et al., 1998; McInerney et al., 2006; Nauta & Epperson, 2003). A recent study concerning STEM major choice,

which links high school and college experiences has also taken advantage of the expansion of the CCST to include environmental supports, which are represented by the availability of financial aid, academic integration, and attendance of remediation courses in college (Wang, 2013).

Summary of Framework Theories. The three career development theories utilized in college major choice research have targeted different aspects of students' characteristics and experiences. Holland's theory targets the fit of students' personality with their environments, which in the case of major choice study, is the discipline's academic environment. While personality is shown to influence college major choice, a more refined measure of personality-type scale, which is not available in national longitudinal studies like NELS or ELS, is needed. A broader environmental definition, which includes potential environmental supports and barriers, may add more depth to the conceptual framework. In addition, another limitation of Holland's theory is its omission of any other student inputs such as demographic background, self-efficacy, or education aspirations. One criticism noted concerning Holland's theory and other career development theories is the possible lack of applicability to non-white subjects (Song & Glick, 2004) and women (Trusty et al., 2000).

Although Krumboltz's social learning theory of career decision has been used as conceptual framework for studies dealing with STEM course patterns, the theory does not address the mathematics self-efficacy, interest, and contextual support outside the classroom environment which may support the college major decision process. In contrast, social cognitive career theory (SCCT) has, as its key constructs, self-efficacy beliefs, learning experiences, outcome expectations, interest, environmental supports and

barriers, and choice action. Further, this theory provides the basis to connect individual, environmental, and behavioral variables over time (Bandura & Adams, 1977; Lent et al., 1994; Lent, et al., 2003). SCCT is a more comprehensive theory, which lends itself to the study of the complex nature of the college major choice decision.

Of the three career development theories highlighted in this review, the social cognitive career theory possesses the theoretical constructs, which are expansive enough to include most important parameters cited in the literature to be influential in choice of STEM major. This theory allows for a more comprehensive perspective of STEM major choice by bridging the high school and college years and providing a context for environmental, social, and individual parameters to be examined.

Factors Influencing the Choice of College Major

Empirical studies, which are based in part on the theories discussed, have identified important factors that influence students choice of STEM major in college. These influential factors are organized into three sections: student background characteristics, high school experiences, and college experiences.

Student background characteristics

Gender. Despite the participation of women in higher education having reached an all-time high, the gender gap still remains in certain academic majors. Every study included in this review examines the influence of gender in combination with other important characteristics of students and their environments on the choice of college majors. One approach of tracking the gender gap over the past three decades involves

following the distribution of women and men majoring in specific fields. Changes in the gender gap are captured by comparison in the dissimilarity index in specific fields. Decreasing dissimilarity indices indicate a move toward parity or complete integration for both women and men, whereas movement toward 100% indicates complete gender segregation of a field of study. The dissimilarity index of all-fields from 1965 to 1995 has shown a drop from 40% to 19%, which indicates there was movement toward equality of men and women across all college majors. The largest drop for all categories occurred between 1965 and the mid-1970s, followed by a drop of 10% between 1973 and 1983 for all fields of study except for arts/science/engineering fields. In contrast, the dissimilarity index for the arts/science/engineering fields increased after 1975 until the early 1980s. This movement toward separation of genders was followed by a leveling off and a moderate decline into the 1990s. While other career choices for men and women were merging and approaching parity, the dissimilarity index for arts/science/engineering fields stalled in the mid-1980s (Turner & Bowen, 1999).

Attention to this slowdown in the movement toward gender parity in engineering-science majors in the 1980s is exemplified by a small study focusing on a homogeneous sample of potential science majors from a selective liberal arts college (Ware, Steckler, & Leserman, 1985). The subjects shared similar characteristics of a strong interest in science major prior to college, a similar academic math/science background, and a high level of academic aptitude. Despite the similarities between these students, by the end of their freshmen year only 50% of women declared a major in a scientific area compared with 69% of men. The basic findings of this study will be supported and expanded further by more recent findings, which are included in this review. For women, the

factors, which significantly predicted the choice of scientific fields, included outstanding academic preparation in mathematics, parental support, a need for a lucrative career or influential careers, and positive interactions with others. For this particular group of men only high school grades and certainty about major before entering college was of significance in their choice of major (Ware et al., 1985). In most cases the gender of the student is a robust predictor of academic major. For example, in Simpson's study across all racial/ethnic categories, female students were five times more likely to pursue a health-related degree than a technical degree program such as computer science, engineering, mathematics, or physics (Simpson, 2001).

Race and Ethnicity. In the interest of improving the STEM education pipeline, more attention is focused on increasing the presence of underrepresented minorities. In an early study by Maple and Stage in 1991, a model was developed using the high school experiences of students attending either 4-year or 2-year institutions in 1984 to explain math/science major choices for black and white students. The racial/gender subgroups were examined in the model which included type and number of academic courses planned and completed, future field of study declared in high school, high school grades, and parental influences as predictors (Maple & Stage, 1991). There is some evidence from another study of impact of expected labor returns on college major choice that women regardless of race/ethnicity backgrounds are less likely to choose STEM majors because they have lower economic expectations than men. Black students also appear to be unaffected by the potential expected economic returns from their choice of major (Staniec Ordovensky, 2004).

Gender and Race/ethnicity Interactions. Numerous studies disaggregate their data into subgroups by gender and race/ethnicity (Hispanic males and females, white males and females etc.) in an effort to understand how gender and race/ethnicity intersect in the choice of STEM majors. With a few exceptions (Frehill, 1997; Trusty & Ng, 2000; Ware et al., 1985) most recent studies into STEM major choice disaggregate their data into gender and racial/ethnic subgroups. The much-publicized changes in population demographics in the United States make the study of minority students important as their presence in the STEM fields needs improvement. Differences in the initial choice of natural and physical sciences majors for racial/ethnicity and gender subgroups are reported in a recent study (Dickson, 2010) involving three large universities in Texas. Although the focus of the study is the dynamic process of major choice starting with the initial choice through to the final choice of major, the study does provide some useful insights into the racial/ethnic difference of initial choice of major while controlling for academic preparation (Dickson, 2010). All women are more significantly likely to major in natural and physical sciences than white men even with similar test scores and class rank (Dickson, 2010). This gender gap holds across all the race/ethnic groups studied. The highest probability of majoring in the natural and physical sciences is for Asian females (.069), followed by Hispanic females (.050) and then white females (.017). Hispanic (.013) and Asian (.057) males are more likely to choose natural and physical sciences compared to their white counterparts (Dickson, 2010).

Although females regardless of race are less likely to declare a physical science major when controlling for academic preparation and math attitudes, black females are the only group, which is moving parity with white males in physical science and

engineering fields (Riegle-Crumb & King, 2010). Black males with comparable levels of academic preparation are 2.5 times more likely to declare a physical science or engineering major than white males. When examining solely a biological major vs. a STEM major, white, Black, and Hispanic females and Black and Hispanic males are just as likely to declare a STEM major as white males (Riegle-Crumb & King, 2010).

While Asian Americans as a collected racial group are not an underrepresented minority in the STEM fields, there are differences in representation when they are subdivided into groups by nationality and geographic region. Asian Americans do vary by their national origin, cultural background, socioeconomic status, and immigration pattern in the United States (Song & Glick, 2004). When Asian Americans are disaggregated into Chinese, Filipinos, Korean, and Southeast Asian, some interesting trends are noted when average starting salaries of certain college majors are examined. Since STEM majors have a higher earning potential than, for example, social science and humanities majors, the motivation of future earnings is an interesting perspective for choice of academic major. With the exception of Korean women, women from the other three Asian groups chose college majors that have higher earning potential than white females. Southeast Asian females chose the most lucrative major of the Asian American females. This is very consistent with the tendency of Asian American women to enter non-traditional female occupations at a higher rate than white females (Leung, Ivey, & Suzuki, 1994). In contrast, there was very little difference between ethnic groups for men with the exception of men from Southeast Asia, who tend to choose the most lucrative majors.

Socioeconomic Status. Family socioeconomic status (SES) is an integral part of the explanation of how women and minority students view educational opportunities and decide on education choices (Oakes, 1990). The composite SES variables including family income, parental education level, and parental occupation prestige are used in the majority of studies in this review. One exception is Song's study of Asian American's college major choices. SES is defined in terms of the family income and the mother's educational level (Song & Glick, 2004). Trusty et al. (2000) found in the examination the influence of 8^{th} grade academic performance, gender, and SES on educational choice and while SES was the weakest predictor of the three, it was still a moderately strong predictor of major choice for both genders. Both Trusty et al. (2000) and Leppel, Williams, and Waldauer (2001) reported that women are more influenced by SES level in their major choices than men. As SES level increases, women are more likely to choose science/engineering or humanities/social sciences than business. This trend was also supported when college majors were classified using Holland's categories to classify college major types. The higher the SES level of women, the more likely they would choose non-traditional majors like science, medicine and engineering (I / investigative majors) (Trusty & Ng, 2000; Trusty et al., 2000). Men, on the other hand, were more likely to choose a business major as SES increases (Leppel et al., 2001).

Some contradictory findings on the role of SES in choice of major are reported when majors are more broadly categorized into Arts & Sciences majors (math, science, humanities, and social sciences) and vocational majors (engineering, business, pre-professional programs like medicine, law, and architecture) (Goyette & Mullen, 2006). In general, the Art & Sciences majors reported higher SES levels than vocational majors.

Within the A&S major category, there were variations in SES level. Science and math majors reported slightly lower SES than humanities and social science majors. There were significant differences between the SES of engineers, pre-professional majors, and other occupationally oriented majors. Engineering majors had the highest SES among vocational majors. Gender differences along SES levels were also apparent in major choice. Male engineering majors tended to have higher SES than males choosing Arts & Sciences majors (Goyette & Mullen, 2006). The women at the highest SES levels tended to study humanities, whereas men at similar SES levels pursued the social sciences. At the lowest SES levels, both men and women tended to choose a pre-professional program. This appears to contradict the findings from Trusty et al (2000). The finding that students from lower SES levels are more likely to be technical majors is supported by other studies (Ma, 2009). Further, students of lower SES levels tend to select not only technical fields but prefer to choose life/health related majors over humanities and social sciences. Women of lower SES levels tend to seek lucrative technical or life/health related majors. Regardless of SES, men are equally as likely to choose a lucrative major (Ma, 2009).

Interactions of Socioeconomic Status and Race/Ethnicity. The socioeconomic status of different racial/ethnic groups has also been found to influence choice of STEM majors. Trusty et al. (2000) reported different effects of SES among the racial/ethnic groups. Asian Pacific Islander men and women chose Holland I (investigative) type majors (for example: computer science, engineering, medicine architecture, and psychology) more frequently regardless of SES level. African American males traditionally choose more S (social) type majors (education, social work, and nursing).

However, the higher the SES level, the less likely African American males would choose S (social) majors. At the highest SES levels, African American males were more likely to choose I (investigative) majors. White males with high SES levels were least likely to choose I (investigative) majors among all racial groups. Hispanic students at lower to middle SES levels choose E or enterprising majors (such as business) more often than expected. Following similar trends of African American and white at higher SES levels, Hispanic students are more likely to choose I (investigative) majors (Trusty et al., 2000; Trusty et al, Ng, & Plata, 2000). Contrary to the results reported by Trusty et al., Ma (2009) reported no difference between racial minorities of varying SES levels. Lack of significance of SES on racial/ethnic minorities is also supported by another study investigating racial difference in academic majors (Simpson, 2001; Ma, 2009).

High School Experiences

Although many factors are relevant in the decision-making process, which students undertake in choosing a STEM major, academic preparation and achievement is of particular importance for students desiring a STEM career. Unlike many majors, advanced courses are often required for admission into many STEM undergraduate programs. Not only must the academic groundwork be accomplished during the middle school and high school years, success in these courses contributes to students' self-confidence in their quantitative skills (Oakes, 1990). Academic preparation means more than just taking the right courses. The types of learning experiences in the classroom and outside the classroom are also relevant to the decision-making process.

Interest in STEM. Interest in STEM fields often begins very early in the education pipeline. Focus groups of underrepresented minorities who were pursuing a

career in scientific research revealed that their interest in science often started early in childhood with a fascination of things in nature like stars, butterflies, an early interest science and math or just wanting to know how things work (Hurtado, Cabrera, Lin, Arellano, & Espinosa, 2009). Other studies confirm that interest in science began well before entering middle school (Maltese & Tai, 2010). Similar findings were noted from engineering students who chose engineering majors based on interest in and aptitude for science/math in high school (Suresh, 2006-2007). Science efficacy and science interest of high school girls who attended a science/mathematics/engineering career conference was found to predict choice of a science major (Nauta & Epperson, 2003). Same interest trends hold for technology majors like information technology (IT), computer science (CS), or management information systems (MIS). Interest in computers before college was a common characteristic of the majors. CS majors made their decision about choice of major during high school, whereas MIS majors made their decision about choice of major during college (McInerney et al., 2006; Downey, McGaughey, & Roach, 2009). In general, interest in majoring in STEM fields upon entering college is a powerful predictor of the choice of STEM major after two years of college for students beginning at 4-year and 2-year institutions (Wang, 2013).

STEM Course Taking. The study of mathematics is of particular importance for potential STEM majors. The quantity and level of mathematics and science courses are a critical part of the educational pathway leading to a STEM college major. A number of studies have explored the effect of the science and math curriculum on choice of the STEM fields (Trusty, 2002; Stanton, 2010; Maple & Stage, 1991). Science/math curriculum influences STEM choice major for all racial/gender subgroups (Maple &

Stage, 1991). Research studies have found women taking the most challenging math courses in high school like trigonometry, pre-calculus, and calculus were more likely to choose a STEM major. For potential engineering students, high school mathematics was particularly important for women, with each additional year of high school math women were 2.5 times more likely to choose an engineering major (Frehill, 1997). Calculus was an especially influential course for potential female STEM majors. The effect of advanced math courses was independent of background variables (SES, race/ethnicity), early science/math performance, and education attitudes and behaviors (math self-perception, homework habits, computer use) (Trusty, 2002). Math cognitions of females are weaker, relative to math related coursework, than male students. This is particularly important since math-related cognitions are related to educational choices like academic majors (Betz & Hackett, 1983) Course-taking patterns had a weaker effect on men; only taking high school physics had a positive effect on choice of SME major (Trusty, 2002). Students who were required to complete at least three math state mandated high school credits or higher were more likely to pursue a STEM major than those who had fewer math credits required for high school graduation (Stanton, 2010).

The number of science courses taken in high school also influences the choice of academic major. Except for health-related majors, the more science courses taken the more likely students will choose technical programs over business, public service, and liberal arts degrees. For every science class taken students are up to 40% less likely to choose business, public service or liberal arts areas of study compared to technical programs. This trend holds over all racial/ethnic categories (Simpson, 2001; Trusty, 2002).

Focus groups of traditional age computer science, computer engineering and information technology majors emphasized that experience and experimentation with computers during middle and high school years was very influential in their choice of field of study. Some students in the focus groups cited that taking advanced placement (AP) high school programming classes and technology classes influenced their choice of computer science and technology majors in college. Where experimentation was important for male students, female students who are currently underrepresented in IT fields are more likely to view technology majors more favorably if they can make a connection between the technology and realistic problems that affect people (McInerney et al., 2006).

Math self-efficacy. Mathematics self-efficacy and ability are particularly important for women and minorities. Without the solid foundation provided by higher level mathematics and science courses, the probability of even having the confidence to pursue a STEM major is significantly decreased (Betz & Hackett, 1983; Trusty, 2002; Stanton, 2010). Positive perceptions of mathematics achievement stemming from learning experiences in high school led both men and women toward Holland I (investigative) majors such as engineering and the sciences (Trusty & Ng, 2000). Men are more likely than women to believe their math and science preparation is better than most of their peers (Leslie et al., 1998). Math self-efficacy was reported to exert a positive albeit indirect effect on STEM major choice of students attending 4-year institutions by positively influencing their interest in STEM in high school. The effect of math self-efficacy on interest was weaker for community college students (Wang, 2013).

Academic Performance. Academic performance in high school influences the choice of STEM college major. Indicators of academic performance, which are most valuable in the identification of potential STEM students are 8^{th} grade cognitive text, SAT mathematics scores, high school grade point average, and to a lesser extent SAT verbal scores (Nicholls, Wolfe, Besterfield-Sacre, Shuman, & Larpkiattaworn, 2007). For example, in the case of SAT scores, a study using students from twelve academically selective colleges found high verbal SAT scores with low math SAT scores indicated a strong likelihood that students will major in humanities compared to other majors (Turner & Bowen, 1999). An increase in verbal SAT with constant math scores increased the probability of choosing biology major over economics in both men and women. As math SAT scores for men and women increase, the likelihood of majoring in engineering or physical sciences also increased (Turner & Bowen, 1999). Math SAT scores are also important for women in choice of science majors (Ware et al., 1985). These findings concerning SAT scores further support the importance of mathematics for students in the STEM fields. Similar findings were reported concerning math achievement, which was measured by the standardized 12^{th} grade math exam scores. Math achievement has a positive impact on entrance into the STEM fields for both students beginning at 2- and 4-year institutions (Wang, 2013).

College experiences

Financial Aid. Rising tuition costs and difficulty finding ways to fund the costs of postsecondary education is another hurdle facing today's students. Examination of the effects of college costs (tuition minus aid) in three large public institutions found that higher net college costs increased the probability of students choosing professional

majors (business, law, and architecture) and decreasing the probability of choosing science majors (Slater, 2011). Types of aid also have some effect on choice of major. When students received loans and merit aid they were more likely to choose science as their major. Students receiving grants were less like to choose professional majors. Overall higher aid promotes the choice of technically difficult majors that require additional time in college (Slater, 2011). While financial aid at 4-year institutions positively impacts the entrance of students into the STEM fields, one study found receipt of financial aid had no effect on community college students (Wang, 2013).

Faculty and student interactions. Faculties fulfill multiple roles on campus for students as instructors, advisors, and source of guidance, support, and information. The impact of faculty/advisors and student interactions has received little attention so far in the college major choice literature even though these type of interactions have been well documented as having positive influences on educational outcomes like academic achievement, educational aspirations, self-concept, academic performance, racial tolerance and persistence (Kim, 2010; Kim & Sax, 2011; McArthur, 2005; Pascarella & Terenzini, 2005; Rask & Bailey, 2002; Thompson, 2001). Recently, faculty/advisors interactions with students have been included in a STEM major choice model tested on students attending 4 year institutions. These faculty/advisor interactions with students produced a positive effect on choice of STEM major for all students (Wang, 2013). Faculty-student interactions are different for community college students since the classroom is often the main contact for these students on a community college campus (Chan, 2005; Hagedorn, Maxwell, Rodriguez, Hocevar, & Fillpot, 2000). Their social involvement on campus is often low in view of the fact that they are commuters and often

have family and employment demands competing for their time. A recent study found faculty-student interaction negatively affected entrance community college students into STEM fields (Wang, 2013). However, this finding for community college students may be more the result of the complexity of faculty-student interactions and limitations of the data used in the study, which focused on faculty/student interactions outside of the classroom (Wang, 2013).

Education Aspiration. Degree aspiration and perceived college readiness in math and science have been reported in a recent STEM major choice study to positively influence the decision to pursue STEM majors of students attending 4-year institutions (Wang, 2013). Science and math majors tend to have a high degree of aspiration than other disciplines (Ware et al., 1985). Inclusion of degree expectations into STEM major choice model development may provide insight into a student's commitment to their major; thus providing further understanding into the entrance of students to the STEM fields. Aspiring to a graduate degree for 4-year college students is seen as a motivational issue, which indicates a student's level of commitment to educational goals and works to sustain interest as they pursue their educational goals. The same effects were not observed for community college students (Wang, 2013).

College Readiness. Studies suggest college readiness may influence choice of college major (Rosenbaum, 2001). Perceived college readiness in math and science by students is thought to give students the needed support and confidence to choose STEM majors. College readiness in these two critical academic disciplines for STEM fields suggests alignment between high school academics and college expectation is critical for the success of STEM majors (Wang, 2013). Perceived science readiness had a positive

impact on 4-year college students but not community college students. Perceived math readiness was insignificant for students at both types of institutions (Wang, 2013).

Summary and Critique of Previous Literature

Previous empirical studies have identified important factors, which influence the selection of a college major during the early years of college. These factors fall into the following categories: (a) background characteristics such as gender, race/ethnicity, socioeconomic status, and parental characteristics; (b) interest in STEM; (c) pre-college experiences like academic preparation, math efficacy, and academic achievement; (d) college experience such as financial aspects, faculty-student interactions, education aspiration, and college readiness. The majority of the studies include the influence of the most important demographic characteristics such as gender, race/ethnicity, and socioeconomic status on the decision-making process leading up to the initial choice of a STEM major. With the push to diversify the STEM pipeline, most of the recent research involving academic major choice note differences in race/ethnicity groups by gender.

The majority of research effort in college major choice has emphasized pre-college experiences. Few studies attempt to bridge the secondary and post-secondary experiences into a comprehensive college major choice model. With the exception of financial aid and tuition issues (Slater, 2011) and faculty/student interactions (Wang, 2013), college major choice models in the research literature do not include the first years of postsecondary education, which can be an important transition period for students thinking about committing to their chosen college major. As already noted in some studies, even interested, highly academically qualified students drop out of the STEM education circuit upon entering post-secondary (Bettinger, 2010). Studies involving

parameters, which might prevent this leakage during the first years of college by providing the support system students require, will help educators and policymakers understand the college major choice process and maintain the needed reservoir of STEM majors.

Only one of the studies cited in this review concentrated solely on students who attend community colleges as their first postsecondary institution. All the other college major choice studies focus on 4-year college students exclusively or combine 2- and 4-year student populations. Many students who attend community colleges differ from their cohorts attending 4-year institutions in terms of academic goals and expectations, academic preparation, and family background and support. Community colleges attract a diverse population of students to its doorsteps with their open access policies, low tuition cost, flexible scheduling, and geographic accessibility (National Research Council, 2012). With growing importance placed on community colleges as a pathway to STEM degrees, more research effort should be directed toward investigating the parameters involved in the choice of college major by these cohorts of students.

Data Used in Previous Research

The data sources for studies examining college major choice are evenly distributed between institutional data and national longitudinal data. Institutional data, primarily from single institutions, includes small select colleges and large research institutions. The most extensively-used national longitudinal databases are National Education Study of 1988 (NELS: 88) and High School and Beyond (HS&B). A few other studies have used data from Baccalaureate and Beyond Survey (B&B), College and

Beyond, Beginning Postsecondary Students (BPS), Cooperative Institutional Research Program (CIRP), and National Longitudinal Survey of Youth (NLSY). Data from longitudinal studies is particularly well suited to study students' experiences over their secondary and postsecondary years. The majority of the studies, however, have used data from older studies such as NELS: 88, which includes 1994 seniors and 1996 postsecondary students and HS&B, which includes 1980 senior and 1982 sophomore cohorts and postsecondary students in 1982 through 1986. Longitudinal studies like Education Longitudinal Study of 2002 (ELS: 2002), which have more current data available would be a more appropriate and informative source of data when studying community college students. This is especially relevant as the importance of community colleges as a path to a STEM degree is a recent trend and attendance in general of communities college has increased by 21% since 2007 (Mullin & Phillippe, 2011) .

Data

ELS: 2002 is the most recent study of the transition of American secondary students to postsecondary education and the workforce. ELS: 2002 is based on the three preceding studies conducted by the National Center for Education Statistics: The National Longitudinal Study for the High School Class of 1972 (NLS: 72), High School and Beyond (HS&B: 80), and the National Education Longitudinal Study of 1988 (NELS: 88). While ELS: 2002 is designed to compare with these previous studies it also adds insight into a new decade of students and their experiences. The base year of 2002 (BY 2002) sampling is as follows: 750 schools were selected first followed by random selection of tenth grade students in each school totaling over 15,000 students. High school sophomores were surveyed in the spring term of 2002. In each school, the

principals, head librarian or media center directors, and math and English teachers for every student included in the study answered questionnaires. The parents of all students included in the study were also surveyed. Both non-public schools (Catholic and private) and Asian students were sampled at a higher rate in order to have sufficient sample sizes for group comparison. The first follow-up (F1) survey occurred in spring of 2004 when most students were in their senior year of high school (12,400). Some students included in F1 had completed high school early, dropped out (1,300), or transferred to other schools (1,100). The F1 sample was "refreshed" by giving students who were out of the country or in other grades due to skipping grades or falling behind the opportunity to participate in the study. The first follow-up included high school transcripts for grades 9-12, ACT/SAT scores, and attendance. The second follow-up (F2) of the study occurred in 2006 and included students who were respondents in both the base year and the first follow-up. Many of these students in F2 were in their second year of college, had never attended college, or were in the workforce (National Center for Education Statistics, 2013)

The Proposed Study

The proposed model for this study is based on the social cognitive career theory and will be well suited to understand the impact on STEM major choice by demographic parameters, math and science preparation, STEM interest, and math–self efficacy and college experiences, which support STEM majors. The model (see Figure 1 on page 43) will include four clusters of variables: student background characteristics, high school experiences, college experiences, and choice of college major.

Variables

Outcomes variable. All studies reviewed organize college majors into varying categories such as humanities, science, social science, and professional majors or as quantitative or non-quantitative majors. While these variations in outcome variables can be informative, for the purpose of this study the outcome variable will be a dichotomous variable with science, technology, engineering, and mathematics majors categorized as STEM majors and all other majors as non-STEM majors. The use of STEM/non-STEM categories are particularly appropriate for community college students since they are often placed in science or mathematics tracks instead of more specific majors found in 4-year institutions.

Independent variables

Student Background Characteristics. Background variables are represented by gender, racial/ethnicity, and socioeconomic levels. Socioeconomic level includes parental education level, family income, and parental occupation status. Background variables are included as control in order to assess the effect of other variables in the model.

High school experience. Measures of academic preparation, self-efficacy, interest in STEM, and academic achievement are included in this model. The attributes in this category include math self-efficacy, 12th grade math exam, units of math, units of science, and interest in STEM field of study.

College experience. College experience describes another category of variables that are related to STEM college major choice. Two of these variables represent environmental supports during the first two years of college that could facilitate the choice of STEM major. These variables include faculty/advisor-student interactions and receipt of financial aid. The other relevant college experiences include degree aspiration and college readiness in math and science.

Conclusion

Based on the review of prior literature, the development of a STEM major choice, which focuses on bridging the secondary and postsecondary experiences, will expand the understanding of parameters influencing students entering the STEM fields. Using this lens to view part of the STEM education pipeline, the outcomes of this study will assist policymakers and educators in targeting points in the pipeline that are important for the success of STEM students. By targeting community college students, this study fills a void in the research literature and recognizes the importance of their section of higher education as essential for increasing the presence of minorities and women in the STEM workforce.

Chapter III: Research Design

The purpose of this study is to examine how student background characteristics, high school experiences in math and science, and early college experiences affect the choice of STEM major for students attending 2-year colleges as their first postsecondary institution after high school. The majority of research published thus far on the factors influencing choice of major has focused on students attending 4-year institutions. This study will provide insight into the decision-making process of students who begin their initial postsecondary experience at a community college. This study will also develop a model of STEM major choice, which will integrate secondary and post-secondary experiences of community college students. This study will be guided by the following research questions:

1) How do high school experiences such as math self-efficacy, math achievement, interest in STEM, and exposure to math and science influence the choice of STEM major by community college students?

2) How do college experiences such as interactions with faculty/advisor, receipt of financial aid, degree aspiration, and perceived college readiness in math and science influence the choice of STEM major by community college students?

3) Do these effects of high school and college experiences on STEM major choice vary by gender and race/ethnicity among community college students?

Research Model

The conceptual model is based on the social cognitive career theory as theoretical framework. The major constructs in the proposed model will include:

- Student background (gender, race/ethnicity, and socioeconomic status)
- High school experiences (math self-efficacy, 12^{th} grade math exam, units of math, units of science, and interest in STEM field of study)
- College experiences which represent support parameters (degree aspiration, student-faculty interactions, financial aid receipt, and perceived college readiness resulting from high school preparation in math and science)

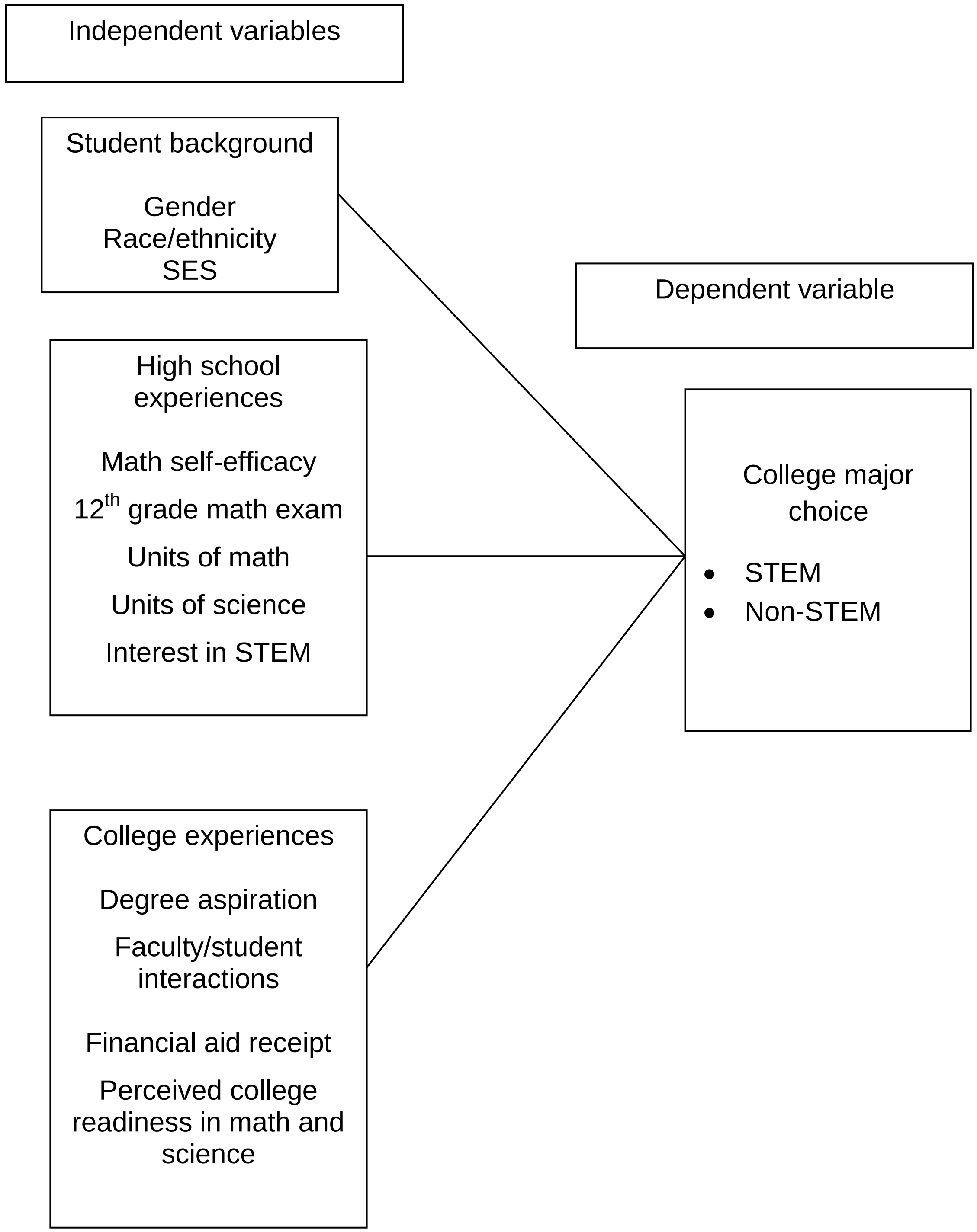

Figure 1. Proposed Research Model for STEM College Major Choice

Data Source and Sample

This study will use data from the Education Longitudinal Study of 2002 (ELS: 2002). ELS: 2002 is a national study, which follows a cohort of students beginning with a baseline survey of over 15,000 students who were high school sophomores in the spring term of 2002. The first follow-up surveys occurred in 2004 when most students were high school seniors. The second follow-up occurred in 2006 when most students were in up to their second year of postsecondary education. Since the ELS:2002 is a longitudinal study with specific data on high school experiences such as academic performance, math/science achievement, course-taking patterns, and STEM interest as well as postsecondary experiences such as education aspirations, math and science course taking, student-faculty interactions, and financial aid. Importantly, this database is very current, which will be particularly key in the study of community college students since the prominence of community college pathway for STEM majors is a recent trend.

Moreover, this study will focus on students who participated in the second follow-up survey and attended a 2-year institution by 2006. Participating students in this study will also have declared a major by 2006. Students who transferred to a 4-year institution or dropped out of the postsecondary education pipeline before declaring a major in 2006 will be excluded.

The missing data issue will be treated using a multiple imputation method (MI). This method is more advantageous over other methods, which exclude cases with missing data, replace missing variable values with variable mean of non-missing values, or substitute each missing variable with value imputed from the variable mean of complete

cases (simple imputation). MI method of treating missing data allows the researcher to overcome uncertainty resulting from a single imputation method. The missing at random (MAR) data will be replaced by multiple values from distribution specified by the researcher. The first step of MI is production of a random set of values, which will reflect uncertainty due to missing values. Replacements of missing data from this set of values will generate multiple datasets. Each complete data set is subjected to binary logistic regression analysis. Finally, inferential results from each dataset will be combined for inference.

Validity and Reliability

The majority of items in ELS: 2002 were based on earlier studies such as National Education Study of 1988 (NEL:88) and High School and Beyond (HS&B). Numerous studies have been conducted based on these datasets so the measurement characteristics are established in the literature. Data quality of math assessment tests and transcript data reliability and completeness are also documented by published reports (Bozick & Ingels, 2008).

Research Variables

The purpose of this study is to examine how student demographics, high school, and community college experiences impact the choice of a STEM major. The research variables for this study are divided into two groups: outcome variable and independent variables. Further details concerning variable description, labels, and recoding are found in Appendices A and B.

Outcome Variable

The outcome variable in this study is a dichotomous variable indicating whether a student chooses a STEM or non-STEM major after up to 2 years of remaining in community college. The college major variable will be recoded in order to collapse all STEM majors into one variable, which is recoded as 1, and all other majors will be designated as non-STEM majors recoded as 0.

Independent Variables

Student background characteristics.

- Gender (A categorical variable indicating student gender. In this study, it will be recoded into a dichotomous variable with Female as the reference group).
- Race/ethnicity (A categorical variable measuring student race/ethnicity. This variable is recoded into dummy variables, in which white students will be treated as the reference group).
- Socioeconomic level composite (A continuous variable which is a composite of parental education level, family income, and parental occupation status.)

High school experiences.

- Math self-efficacy (A categorical variable based on two questions concerning beliefs on math test taking and mastery of math skills. The math self-efficacy variables will be recoded as high, middle, and low levels of math self-efficacy.)

- 12th Grade math achievement (A continuous variable is the score on a 12th grade standardized math test).

- Units of math (A continuous variable measuring the total of Carnegie units of math taken during high school. A Carnegie unit is equivalent to a one-year academic course taken one period per day for five days per week.)

- Units of science (A continuous variable generated by summing Carnegie units of life science courses and physical science courses taken during high school.)

- Interest in STEM (A categorical variable indicating the intended field of study when first entered college. The field of studies will be collapsed into STEM and non-STEM categories with STEM field of studies recoded as 1 and non-STEM field of studies recoded as 0).

College Experiences.

- Faculty-student interactions (Two categorical variables measuring the frequency of talking with faculty about academic matters outside of class and meeting with advisor about academic plans. The variables will be recoded as 1 for “often” or “sometimes” and 0 for “never”)

- Receipt of financial aid (A categorical variable indicating whether students were offered financial aid during the first year of college).

- Degree Aspiration (A categorical variable indication whether students aspire to a Bachelor’s degree or higher).

- Perceived College Readiness in Math (A categorical variable indicating whether students believed high school math prepared them for study at first postsecondary institution attended. This variable measures how students in college perceive their college readiness in math).
- Perceived College Readiness in Science (A categorical variable indicating whether students believed high school science prepared them for study at first postsecondary institution attended. This variable measures how students in college perceive their college readiness in science).

Data Analysis

This study will use both descriptive statistics and binary logistic regression to analyze data. While descriptive statistics characterize the dataset, inferential statistics allow the researcher to determine whether they can generalize findings and interferences that are based on a limited sample to a general population (Gay, Mills, & Airasian, 2009). Before proceeding with descriptive and inferential analysis, the researcher will extract sample from the dataset using SPSS. The appropriate unit of analysis is the student level given that the relationships of student background, academic achievement, interest, course taking, academic integration, and financial aid will be examined. Only students who reported attending community college as their first post-secondary institution and who were still enrolled in community college at the time of declaring a college major in 2006 will be included in the sample. Due to the design of the study, all analysis will be weighed using the appropriate weight panel (F1F2WT) and therefore, the results of study will be generalized to the population of spring 2004 high school graduates who attended postsecondary education at a community college within two years of high school

graduation. Next, the researcher will recode all variables so that the dataset is ready for descriptive and inferential analysis.

Descriptive Analysis

This study will use descriptive statistics to describe the demographics characteristics, high school experiences such as number of math and science units, math efficacy, math achievement, interest in STEM fields, and college experiences such as faculty/student interactions, financial aid, perceived college readiness in math and science, and degree aspiration. Descriptive analysis will include the frequency and standard error of all independent variables in the proposed model.   The method that will be used to characterize the frequencies of the study sample is cross tabulation. Cross tabulation data will compare the characteristics of students who chose STEM or non-STEM majors. The independent variables will be checked for multicollinearity problems. A variance inflation factor (VIF) will be run using the predictors in the study model. If predictors have a VIF values less than 10, then none of the predictors will be highly correlated (Allison, 1999).

Binary Logistic Regression

Logistic regression has been increasingly used in higher education research since the late 1980s. This type of analysis is particularly useful when dealing with categorical outcome variables.   Binary logistic regression is the appropriate type of inferential analysis to develop a model for prediction of a STEM major since the dependent variable, a binary categorical variable, is the choice of STEM major or not.

The binary logistic regression model is based on the following equation with the dependent outcome represented as choice of STEM major or not:

$$log\left(\frac{P(Y=1)}{1-P(Y=1)}\right)= \beta_0+\beta_1X_1+\ \beta_2X_2+\beta_3X_3+_{\dots}+\beta_XX_X$$

Where the log side of the equation is the log of the odds that a student will choose STEM major, β_0 represents the constant of the equation whose value yields P when X is zero, β_1 through β_X represents the coefficient of predictor variables (Gay et al., 2009).

Limitations

There are some limitations to this study, which warrant discussion. First, the use of extant data such ELS: 2002 restricts the research design in certain aspects. Points in the STEM education circuit before the 10^{th} grade are not available for study. Early learning experiences and academic achievement may have far reaching effects on future educational decisions such as entrance to STEM fields. Several variables representing high school experiences have some limitations in the way they are presented in ELS: 2002. For example, interest in STEM fields, which is a variable in this study, can only be measured by intended major declared by students upon entering college. This is a measure of interest at one point in time and does not allow the researcher to examine how interest in STEM develops during high school or earlier in the STEM education pipeline. Questions related to interest during primary and secondary years of education are not available in ELS: 2002. Self-efficacy is a fundamental parameter in SCCT and is part of the theoretical framework for this study. While survey items measuring math self-efficacy are available, measures of science self-efficacy and STEM self-efficacy are not

available and would add depth to the understanding of the role self-efficacy in the model. High scientific and technical self-efficacy have been linked to choice of engineering major (Lent, Brown, & Larkin, 1984).

Secondly, several variables representing postsecondary experiences have some limitations that are noteworthy. Academic integration, which is measured by the student interaction with faculty and advisors, would be more informative with regards to STEM majors if survey items identify the frequency of interactions students had specifically with STEM faculty. Further, other types of interactions with faculty have been identified as important in the literature. The mentoring relationship established between faculty and high school students who are low income, minority, or potential first generation college students while involved in summer research projects or intensive academic STEM college prep have been found to positively impact STEM major choice (Lam, Srivatsan, Doversplice, Vesalo, & Mawasha, 2005; Zhe, Doverspike, Zhao, Lam, & Menzemer, 2010). Missing from the model are STEM course taking in postsecondary institution, which would mirror STEM course taking patterns in high school already in this study model. This data is not currently available in ELS: 2002 until 2014. Transcript data will be available after 2014. Inclusion of STEM course taking patterns have been reported as an indication of a student's commitment to staying in the STEM circuit. Strength of commitment to a STEM major is reflected in the type of classes students take in their very first semester at college, which supports the inclusion of this parameter in this model (Bettinger, 2010) .

Thirdly, several variables in the research literature thought to be influential in the choice of STEM major are not included in this study model. (Leppel et al., 2001; Ware et

al., 1985; Leslie et al., 1998). Parameters dealing with parental involvement (Oakes, 1990), encouragement and support are not included in this study (Scott & Mallinckrodt, 2005). While these specific measures are not available in the ELS: 2002, the SES composite variable used in this model does include parental education level, family income, and parental occupation status. Personal student characteristics such as personality (Porter & Umbach, 2006; Pulver & Kelly, 2008) and value system (Frehill, 1997; Lackland & De Lisi, 2001; Harris, Cushman, & Anderson, 2009) are not represented in the study model. Survey questions are not available to reliably measure personality characteristics and values in ELS: 2002 dataset. Expected financial returns or market value of the college major is not included in the proposed model since that type of data is not included in the ELS database (Staniec Ordovensky, 2004; Boudarbat, 2008). Finally, collapsing all majors into STEM and non-STEM may lose some important information about potential differences in pathways or predictors for different fields, for example, engineering, biological sciences, or computer sciences (Riegle-Crumb & King, 2010)

Lastly, the number of STEM majors attending community college as their first postsecondary institution is much smaller than STEM majors in 4-year institutions, which have been studied more extensively. Their resulting smaller sample size for this study introduces potential for bias in reported odds ratio, which may lend to overestimation of odds ratio of predictors in the proposed STEM major choice model.

Summary

This chapter outlined the methodology that used in this research. A description of the ELS: 2002 database along with the independent and dependent variables were presented. In addition plans for descriptive and inferential analysis were described along with limitations of the study. Chapter IV will present the analysis. Chapter V will discuss the interpretation of findings and implications of these findings for improvement of the STEM education circuit and STEM workforce. Suggestions for the future will be discussed.

Chapter IV: Results

As discussed in Chapter Three, this study is guided by research questions, which focus on the impact of student demographics, high school, and college experiences on the choice of STEM major and how these parameters vary by gender and race/ethnicity. The results in this chapter are organized in two sections. The first section presents the descriptive statistics for all the variables in this study. The descriptive statistics include mean, range, frequency, standard error, and variance inflation factor (VIF) of all independent variables in the model. The descriptive statistics also include cross tabulations to compare the characteristics of STEM and non-STEM majors, and comparison of science units taken in high school by gender and race/ethnicity. The second section presents the results of the analysis of the STEM college major model using binary logistic regression. This analysis will help understand the impact of student demographics, high school, and college experiences on the choice of STEM college major for community college students.

Descriptive Statistics

Tables 1, 2, and 3 describe all the variables included in the STEM college major model. Table 1 tabulates the VIF values for all predictors in the model. Table 2 summarizes the descriptive statistics of all the categorical variables and Table 3 presents descriptive statistics of the continuous variables. Table 4 presents cross tabulations comparing characteristics of STEM and non-STEM majors. Finally, Table 5 presents statistics on number of science units taken by gender and race/ethnicity groups.

The reported range of VIF values in Table 1 is 1.06 to 4.86. As the range of VIF values for all variables are less than 10, none of the predictors are highly correlated.

*(*Allison, *1999)*. This indicates that a serious multicollinearity problem does not exist for this model.

Table 1 Variance Inflation Factor (VIF) Values for Independent Variables in Model

Variables	VIF
Student Characteristics	
Gender	1.15
SES	1.16
Race and Ethnicity	
African American	1.24
Asian/Pacific Islander	1.06
Hispanic	1.23
Other minorities	1.04
Math self-efficacy measures	
Math testing efficacy high	4.86
Math testing efficacy mid	3.95
Math skill level efficacy high	3.66
Math skill level efficacy mid	2.94
Academic preparation	
12^{th} grade math exam	1.47
Math units	1.19
Science units	3.05
Interest in STEM	
Intended major in STEM fields upon entering college	1.09
Postsecondary experiences	
Aspired to Bachelor or higher	1.09
Offered financial aid	1.09
Talks often to faculty	1.17
Talks often to advisor	1.18
Perceived College Readiness in Math	1.16
Perceived College Readiness in Science	1.16

As the statistics in Table 2 demonstrate, female students (57.48%) make up the majority of the students beginning their postsecondary education in community college. White students (56.85%) comprise the majority of the sample with African American students representing 11.41%, Asian 11.91%, Hispanic 15.46% and other minorities 4.36 %. The sample demographic profile is similar to 2013 student demographics reported by the American Association of Community Colleges (AACC) (2013). The variables representing high school experiences in Table 2 include math self-efficacy measures and interest in STEM upon entering community college. The measures of math self-efficacy for math test taking found students are evenly distributed between low, mid and high levels with 31.23%, 32.11%, and 32.98% respectively. Some differences are noted with how students perceived their math skills with 51.00 % of students in the sample at a high level of math self-efficacy followed by 38.84% in the mid-level and 16.77% in the low level. The data demonstrates that 10.54 % of students expressed interest in majoring in the STEM fields upon entering community college. The variables representing community college experiences include education aspiration, perceived preparation by high school science and math courses for college, academic integration, financial aid, and choice of major. The data finds that 75.37% of students aspire to earn a Bachelor's degree or higher. A higher percentage of students indicate they perceived high school math courses (42.33 %) prepared them for college compared to high school science courses (34.76%). As a measure of academic integration the majority of students interact with faculty (74.38%) and advisors (79.05 %) frequently. Almost half of students (46.45 %) were offered financial aid in their first year of college. Students declaring STEM

majors in 2006 comprise 12.47 % of the sample, whereas 87.53% of students declared non-STEM majors.

Table 2 Descriptive Statistics of Categorical Variables (n=1604)

Variables	Weighted Percentages	Standard Error
Student Characteristics		
Gender		
Female	57.48	.01
Male	42.52	.01
Race and Ethnicity		
African American	11.41	.01
Asian/Pacific Islander	11.91	.01
Hispanic	15.46	.01
Other minorities	04.36	.01
White (Reference Group)	56.85	.01
Math self-efficacy measures		
Math testing self-efficacy high	32.98	.33
Math testing self-efficacy mid	32.11	.01
Math testing self-efficacy low (reference group)	31.23	.01
Math skill level self-efficacy high	51.00	.01
Math skill level self-efficacy mid	38.84	.01
Math skill level self-efficacy low (reference group)	16.77	.01
Interest in STEM		
Intended to major in STEM fields upon entering college	10.54	.01
Postsecondary experiences		
Aspired to Bachelor or higher	75.37	.01
Offered financial aid	46.45	.01
Talks often to faculty	74.38	.01
Talks often to advisor	79.05	.01
Perceived College Readiness in Math	42.33	.01
Perceived College Readiness in Science	34.76	.01
Declared STEM majors	12.47	.01
Declared non-STEM majors	87.53	.01

Table 3 presents descriptive statistics of continuous variables included in the STEM major choice model. The mean, standard deviation, and range are presented for socioeconomic level, 12th grade standard math exam, and number of math and science units taken during high school. On average students take 1.2 times more math units than science units during high school years. The mean 12th math test score is 48.67 with range of 25.72 to 74.97. The mean of socioeconomic status is 0.003 with range of -1.98 to 1.70.

Table 3 Descriptive Statistics of Continuous Independent Variables (n=1604)

Variables	Weighted Mean	Standard Deviation	Min	Max
Student Demographics				
Socioeconomic Status	0.003	0.65	-1.98	1.70
Academic preparation				
12th grade math test	48.67	8.21	25.72	74.97
High school math units	3.45	1.00	0	7.10
High school science units	2.91	1.08	0	8.20

Table 4 presents descriptive statistics using cross tabulation analysis to compare the characteristics of STEM and non-STEM majors. This analysis includes demographics, high school experiences, and community college experiences of STEM and non-STEM majors. The percentage of male STEM majors is 2.5 times greater than female STEM majors with 19.06 % and 7.59 % respectively. The racial group with the largest concentration of STEM majors is Asian/Pacific Islander at 18.85% followed by other minorities (12.86%), white (12.17%), Hispanic (10.08%) and African American (10.38%). The data illustrates the trend of Asian/Pacific Islander students having a more prominent place among the pool of STEM majors compared to other racial/ethnic groups. These distribution patterns also confirm that fewer African Americans and Hispanic

students declare a STEM major taking these groups out of the STEM education pipeline at this crucial point.

Some noteworthy differences for high school experiences are reported for math self-efficacy measures and interest in STEM fields. Comparison of the measures of math self-efficacy for testing finds more STEM majors are at a high level of math self-efficacy than at middle or lower levels of self-efficacy. In contrast the majority of non-STEM majors are found at the middle and lower levels of math self-efficacy. The STEM majors are predominantly in the high and mid-levels of math skill self-efficacy measures whereas non-STEM majors have a higher percentage in the low math skill self-efficacy category. Interest in majoring in the STEM fields is an important parameter with 63.91% percent of STEM majors expressing interest in STEM upon entering community college. However, more than one-third of students entering community college interested in STEM end up declaring non-STEM majors after two years. Very few students (6.41 %) expressing interest in non-STEM fields upon entering college eventually choose a STEM field as their major.

Description of STEM and non-STEM postsecondary experiences present some trends for education aspiration, academic integration, receipt of financial aid and perceived college readiness. Of the students aspiring to earning a Bachelor’s degree, 87.34% are non-STEM majors and 12.66% are STEM majors. Similar results are reported for students expecting to earn less than a Bachelor’s degree. The proxies for environmental supports in the model are represented as academic integration and receipt of financial aid.

Table 4 Cross Tabulation Analysis of Student Demographics and High School and Postsecondary Experiences, of STEM and non-STEM majors (n=1604)

Variables	Weighted percentages	
	STEM major	Non-STEM major
Gender		
Female	7.59	92.41
Male	19.06	80.94
Race/Ethnicity		
African American	10.38	89.62
Asian/Pacific Islander	18.85	81.15
Hispanic	10.08	89.92
Other minorities	12.86	87.14
White (Reference Group)	12.17	87.83
Math self-efficacy measures		
Math testing efficacy high	17.39	82.61
Math testing efficacy mid	11.84	88.16
Math testing efficacy low (reference group)	12.18	87.82
Math skill level efficacy high	12.84	87.16
Math skill level efficacy mid	13.00	87.00
Math skill level efficacy low (reference group)	10.04	89.96
Interest		
Intended to major in STEM fields upon entering college	63.91	36.09
Intended to major in non-STEM fields upon entering college	6.41	93.59
Postsecondary experiences		
Aspired to Bachelor's or higher	12.66	87.34
Aspired to degree lower than Bachelor's	11.90	88.10
Financial aid receipt	12.48	87.52
Talks often to faculty	11.82	88.18
Talks often to advisor	12.38	87.62
Perceived College Readiness in Math	15.81	84.19
Perceived College Readiness in Science	15.22	84.78

The measures for academic integration indicate on average 12% of STEM majors and 88% of non-STEM majors interacted frequently with faculty and advisors. The same

trend holds for STEM and non-STEM majors in regard to receipt of financial aid as academic integration. Finally, on average 15% of STEM majors and 85% of non-STEM majors perceived their high school science and math courses prepared them for college.

When comparing high school academic preparation in Table 4, STEM majors on average take more units of both math and science than non-STEM majors. Further, STEM majors score higher on average on 12th grade math tests compared to non-STEM majors. Concerning students demographics, STEM majors (.003) report higher mean SES values than non-STEM majors (-.0003).

Table 5 Mean of SES and Academic Preparation Variables by STEM and non-STEM Majors

Variables	STEM majors	Non-STEM majors
Student Demographics		
Socioeconomic Status	.003	-.0003
Academic Preparation		
12th grade math test	51.69	48.23
High school math units	3.68	3.42
High school science units	3.28	2.86

Finally, the average number of science units taken by high students is presented in Table 5 by gender and race/ethnicity. There are no differences in number of science units taken by male and female students. However, race/ethnicity subgroups report differences in the number of science units taken in high school. White and other minorities (3.00) take the highest number of science units of all race/ethnicity subgroups followed closely by Asian/Pacific Islander students (2.91). African American (2.80) and Hispanic (2.69) students take the fewest number of science credits in high school. The number of science

units is presented in the descriptive section because of its significance in the STEM major choice model as reported in Table 6.

Table 6 Mean of science units taken in high school by gender and race/ethnicity

Variables	Mean	Standard deviation	Min	Max
Gender				
Female	2.91	1.10	0	8.20
Male	2.91	1.05	0	8.20
Race/ethnicity				
African American	2.80	0.97	0	7.10
Asian/Pacific Islander	2.91	1.35	0	6.00
Hispanic	2.69	1.00	0	5.00
Other minorities	3.00	1.09	0	5.50
White (Reference)	3.00	1.04	0	7.00

Binary Logistic Regression

In order to determine the impact of student demographics, high school experiences, community college experiences, and interactional effect of gender and race/ethnicity with predictor variables on the choice of STEM major, the STEM major choice is run using binary logistic regression. Table 7 presents the findings of estimated odds ratio, standard error, and significance of each variable used in the analysis. Odds ratios larger than one indicate a positive relationship of variable with choice of STEM major, while odds ratios smaller than one indicates a negative relationship (Osborne, 2008).

The demographic parameters included in the model are gender, race/ethnicity, and socioeconomic status. The significant findings in this group of variables reside in the categories of gender and race/ethnicity of the students. First, gender is statistically significant and negatively impacts the choice of STEM major. The odds of female

students declaring a STEM major after two years are 40% lower than for their male counterparts (OR= .60, $p < 0.05$). Concerning the impact of race/ethnicity in the proposed model, African American, Hispanic, and American Indian/ Alaskan native/multi-racial categories are not statistically significant. The only race/ethnicity group found statistically significant in this study is Asian/Pacific Islander students. The odds of Asian/Pacific Islander students declaring a STEM major are two times the odds of white students declaring a STEM major (OR= 2.01 , $p < 0.05$). Finally, the continuous variable representing socioeconomic status (based on parent's education and occupation, and family income) is not statistically significant in the model.

Among the high school experience parameters in the model two variables representing academic preparation and interest in STEM are significant. First, the results from the binary logistic regression analysis showed that a significant and positive relationship exists between choice of STEM major and interest in STEM major upon entering community college. For students who enter community college with the intention of majoring in a STEM field, the odds of choosing a STEM major after two years is 25 times the odds of choosing a non-STEM major (OR=25, $p<0.001$). The resulting interest variable is the most powerful predictor in the proposed model. Secondly, concerning the total number of science units taken by high school students during their 4 years of high school, the relationship with choice of STEM major is also positive and significant. Interpretation of the results finds that an increase by one unit of

the mean of science units is associated with a 21% increase in the odds of a student choosing a STEM major. (OR=1.21, $p<0.05$). Other variables representing academic preparation such as 12th grade math exam and number of units of math taken during high school are not statistically significant. The proxy variables for math self-efficacy in areas such test taking and mastering math skill at high, middle, and low levels are also statistically insignificant in the model.

The third section of the STEM choice major model focuses on postsecondary experiences of education aspiration, academic integration, receipt of financial aid and perceived college preparedness in science and math. Education aspiration is defined in the study as aspiring to a Bachelor's degree or higher. Environmental supports in conceptual framework of the study are represented as frequency of interactions with faculty/advisors outside the classroom, which is used as a proxy for academic integration and receipt of financial aid. Those variables representing environmental supports and education aspiration proved to be statistically insignificant. Finally, both variables measuring students perceived preparedness by high school science and math courses for their college studies are also not statistically significant in this model.

In the logistic regression model, interaction variables are tested in the model to reveal whether one variable has a differential effect in response to a change with another

variable. In this study interaction terms were incorporated into the STEM major choice model in response to the research question concerning whether high school and college experiences varied by gender and race/ethnicity. A series of over 35 interactions terms were generated from predictor variables and gender or race/ethnicity variables and separately included in the STEM major choice model. As shown in Table 8, the interaction terms resulted from combining gender, African American, Asian, Hispanic, and white variables with variables such as intended major, socioeconomic status, science units and math units, math self-efficacy, and Bachelor degree expectation. None of these variables is statistically significant predictors of choice of STEM major for community college students.

Table 7 Logistic Regression Analysis Predicting the Choice of STEM Major

Independent Variables	Odds Ratio	Significance	Standard Error
Female	0.60	*	0.14
Socioeconomic level	1.02		0.17
African American	1.15		0.44
Asian/Pacific Islander	2.01	*	0.68
Hispanic	1.49		0.54
Other minorities	1.75		0.93
Math testing efficacy high	1.54		0.54
Math testing efficacy mid	1.10		0.37
Math skill level efficacy high	0.88		0.73
Math skill level efficacy mid	1.19		0.86
Interest in STEM fields upon entering college	26.11	***	6.63
12th grade math test	1.03		0.02
Units of math	1.01		0.13
Units of science	1.21	*	0.11
Aspired to Bachelor's or higher	0.72		0.18
Talks often to faculty	0.76		0.20
Talks often to advisor	0.99		0.27
Financial aid receipt	1.10		0.25
Perceived College Readiness in Math	1.38		0.22
Perceived College Readiness in Science	0.94		0.25
Note: Significance: $p < 0.001$***; $p<0.01$**; $p< 0.05$*			

Table 8 Interaction Variables Tested for STEM Major Choice Model

Interaction Variable Name	Variables Used to Generate Interaction Variables
femintmjor	Gender and Intended college major upon entering postsecondary education
blackintmjor	African American and Intended college major upon entering postsecondary education
asianintmjor	Asian and Intended college major upon entering postsecondary education
hispanicintmjor	Hispanic and Intended college major upon entering postsecondary education
whiteintmjor	White and Intended college major upon entering postsecondary education
femblack	Gender and African American
femasian	Gender and Asian
femhispanic	Gender and Hispanic
femwhite	Gender and White
femses	Gender and Socioeconomic status
blackses	African American and Socioeconomic status
asianses	Asian and Socioeconomic status
hispanicses	Hispanic and Socioeconomic status
whiteses	White and Socioeconomic status
femmathunit	Gender and Math units
blackmathunit	African American and Math units
asianmathunit	Asian and Math units
hispanicmathunit	Hispanic and Math units
whitemathunit	White and Math units
femefftest	Gender and Math self-efficacy
femefftest	African American and Math self-efficacy
asianefftest	Asian and Math self-efficacy
hispanicefftest	Hispanic and Math self-efficacy
whiteefftest	White and Math self-efficacy
femsciunits	Gender and Science units
blacksciunits	African American and Science units
asiansciunits	Asian and Science units
hispasciunits	Hispanic and Science units
whitesciunits	White and Science units
femadegex	Gender and Degree expectation
blackdegex	African American and Degree expectation
asiandegex	Asian and Degree expectation
hispanicdegex	Hispanic and Degree expectation
whitedegex	White and Degree expectation

Chapter 5: Conclusions and Implications

Propelling the STEM workforce forward to meet the challenges of the 21st century global economy has captured the attention of leaders in government, business, and science/technology. Recommendations put forth by the National Governors Association addressing STEM workforce issues have highlighted the potential of community colleges as part of a comprehensive approach to build a skilled STEM Workforce (NGA Center for Best Practices, 2011). Community colleges as institutions are uniquely situated in the community to serve ethnic and racial minorities and women who are seen as a crucial part of this century's future STEM workforce. Community colleges are already important in the education of STEM profession with 44% of Bachelor and Master's recipients attending a community college at some point in their education (Tsapogas, 2004). Understanding the needs and challenges of community college students as they traverse the STEM education pipeline is important for education policymakers, administrators, K-12 teachers, and college faculty to ensure the success of students in these institutions. To-date much educational research concerning STEM students is focused on students attending 4-year institutions. Further, the majority of STEM research is focused on K-12 preparation or retention/ persistence of students in the STEM pipeline. Less attention in the literature is devoted to the entrance of students to the STEM fields and very limited attention is focused exclusively on STEM students who begin their postsecondary education at community colleges. This study attempted to develop a STEM major choice model that encompasses high school and college experiences of students starting at community college. This study aspires to enhance the understanding

of parameters that influence the choice of STEM major, which will assist education policymakers, school administrators, K-12 teachers, and college administrators and faculty information, and improvement of policy, programs, and practices. Incorporation of these experiences in the model is based on constructs from the social cognitive career theory (Lent & Brown, 1996; Lent et al., 2003) and parameters found important in the college major choice literature. The model also examined any potential effect by interactions between gender and race on choice of STEM major. The following questions guided the study:

1) How do high school experiences such as math self-efficacy, math achievement, interest in STEM, and exposure to math and science influence the choice of STEM major by community college students?

2) How do college experiences such as interactions with faculty/advisor, receipt of financial aid, degree aspiration, and perceived college readiness in math and science influence the choice of STEM major by community college students?

3) Do these effects of high school and college experiences on STEM major choice vary by gender and race/ethnicity among community college students?

The data for this study came from Education Longitudinal Study of 2002 (ELS: 2002), a national longitudinal study that tracked 10th grade high school students over the next four years from 2002 to 2006 with first follow-up data collection during the spring of 12th grade and second follow-up data two years after high school graduation. The final sample used in this study was made up of 1604 students who enrolled in community colleges as their first postsecondary institution and declared a major by 2006. Based on

the proposed research strategy, the predictor variables were first tested for multicollinearity problem by comparison of VIF values. The second step was to report descriptive statistics on all predictor and dependent variables in the model. In the third step, the data was analyzed using cross tabulations to compare and identify patterns and trends of STEM and non-STEM majors. Next, given the categorical nature of the outcome variable in this model, analysis of independent variables was performed using binary logistic regression to study the effect of high school and college experiences on the choice of STEM major. Finally, interactions of race/ethnicity and gender with independent variables were added to the model to determine if results from the model differed according to these demographic parameters.

This chapter discusses the results presented in Chapter IV followed by discussion of implications for policy, practice, and theory. Finally, suggestions for future research are explored.

Conclusions

Using the social cognitive career theory and insights from the research literature, this study investigates factors affecting the choice of STEM major by students beginning their postsecondary education at community colleges. The proposed model in this study encompasses three areas (a) students demographic; (b) high school experiences; (c) college experiences. The descriptive analysis in this study provides a snapshot of students attending community college as their first postsecondary institution and trends for STEM and non-STEM majors. The largest minority group attending community colleges are Hispanic students. This is consistent with reports that 56% of Hispanic

undergraduates attend community colleges, the highest percentage of any of the minority groups (NGA Center for Best Practices, 2011). The predicted growth of the Hispanic population is from 14% in 2005 to 29% in 2050, thus highlighting the importance of this demographic group in community colleges and ultimately in the STEM professions (NGA Center for Best Practices, 2011). Almost 60% of the students in the study were women, which additionally points to community colleges as a pathway for many women pursuing higher education. Other trends of note among community college students reveal around 11% of students entered college interested in STEM fields, which is comparable with the percentages of students who actually declared a STEM major (12%) two years after high school. With regards to academic preparation, the students in the study sample took on average more math courses than science courses in high school and, interestingly, a higher percentage of college students believed their high school math courses better prepared them for success in college compared with their high school sciences courses. Further, while there were no gender differences in the number of high school science courses taken, some differences were observed between racial/ethnic groups in high school academic preparation. The absolute number of science units was not homogenous across racial/ethnic groups. Asian and white students took on average more science units than African American or Hispanic students with Hispanic students taking the fewest number of science units.

Student demographic characteristics such as racial and gender distribution for STEM majors agreed with published trends that showed Asian students as the dominant racial/ethnic group and men maintain their dominance among STEM majors in

comparison to non-STEM majors. STEM majors are on average from higher socioeconomic levels than non-STEM majors in this study.

One of the most striking differences between STEM and non-STEM majors concerns the intended major of students who are just entering community college. The majority of STEM majors planned to major in a STEM field at the beginning of their postsecondary education. Interestingly, of those interested in majoring in STEM fields when entering college, over one-third ended up in non-STEM majors and two-thirds followed through with their interests and declared a STEM major as of 2006. A very low percentage of students planning a non-STEM major in their first year of college actually declared a STEM major in 2006. In general, STEM majors were better academically prepared than their non-STEM major counterparts when average 12^{th} grade math exam results and average numbers of science and math units are used as a gauge. Measures of math test taking self-efficacy found a higher percentage of STEM majors in the high level compared to non-STEM majors. Similar trends were observed for math skill self-efficacy measures with a higher percentage of STEM majors with students of mid to high levels of self-efficacy than non-STEM majors. Concerning perceived college readiness, neither STEM nor did non-STEM majors report any differences in perceived readiness for college based on science or math high school preparation.

The findings from the binary logistic regression revealed significant results for some student demographic characteristics and high school experiences. The gender of the students revealed a significant finding that being female negatively impacted the choice of STEM major. This finding is not surprising as similar results have been consistently reported in numerous studies of college major choice (Simpson, 2001; Trusty

et al., 2000; Xie & Shauman, 2003). Of the racial/ethnicity subgroups in the model only being Asian was found significant and to positively influence the choice of STEM major compared white students. While this is consistent with other findings, some studies have also reported belonging to other minority groups was a significant predictor of choosing a STEM major (Simpson, 2001, Wang, 2013). In Simpson's study, socioeconomic level was not found to be a significant predictor, although other studies have found it significant (Goyette & Mullen, 2006; Ma, 2009; Trusty et al., 2000).

Intended choice of STEM major upon entering community college was used as a proxy to measure interest in STEM in high school. This parameter was the most powerful predictor of choice of STEM major in this study. Some studies have supported the importance of maintaining interest in STEM during secondary education through their college years (Nauta & Epperson, 2003; Suresh, 2006-2007) while others found that interest begins well before middle school (Maltese & Tai, 2010).

Many prior studies report the positive influences of both math/science learning and achievement and math self-efficacy on choice of STEM major in college (Crisp et al., 2009; Porter & Umbach, 2006; Wang, 2013). Although math course taking and achievement has been found to influence the choice of STEM major in other studies (Frehill, 1997; Trusty, 2002), this study has reported only the number of science courses, which students take during their high school years, is influential in the STEM major decision process. Increasing the number of science courses in high school may increase the likelihood students choose STEM majors in college. Both math achievement and math self-efficacy represented in this study were not found significant, which is inconsistent with published studies that have found positive a relationship among

students attending 4-year colleges. (Betz & Hackett, 1983; Trusty, 2002; Stanton, 2010). This may be explained by the finding in a recent study (Wang, 2013), which reported that the positive effect of math self-efficacy on STEM major choice is indirectly mediated through variables like STEM interest and not directly linked to the major choice decision.

Within the college experiences section of the STEM major choice model, none of the parameters included were found statistically significant in this study. The postsecondary environment supports of the social cognitive career theory are represented as academic integration and receipt of financial aid. The results for financial aid receipt are consistent with the results reported in Wang's recent study of STEM major choice by community college students (Wang, 2013). While receipt of financial aid is important for 4-year college students, community college students may have different views of financial aid. Lower tuition cost, more working students who pay their own tuition, and reluctance of students to take on debt are possible explanations for the lack of impact of financial aid on their college major choice. Given that community college students are most likely to work full time or attend part-time or a combination of both, very few take out student loans (Horn et al., 2006). In addition to financial aid receipt, academic integration was included as an environment support in the study model. Academic integration is reported to positively affect STEM choice for 4-year college students (Wang, 2013). However, the same results are not observed for community college students. Given that the majority of interactions with the faculty occur in the classroom setting in community colleges, the variables representing academic integration in ELS: 2002 are not the optimal measure of the type of academic integration, which is important for community college students. Both perceived college readiness in math and science

were also found insignificant in this study for community college students. The results concerning college readiness in math and science of this study are in agreement with Wang's findings for community college students. Wang's study found only perceived college readiness science positively influenced choice of STEM majors for 4-year college students (Wang, 2013). Education aspiration defined in this study as expecting to receive a Bachelor's degree or higher is not a significant predictor of STEM major. This finding is consistent with results reported in the literature concerning community college students. Four-year college students are reported to be positively influenced by graduate degree aspiration (Wang, 2013). Finally, no significant interaction effects of gender and race/ethnicity with independent variables were observed when the interaction terms were included in the STEM major choice model (Table 7). Therefore, the relationships between high school/college experiences and STEM major choice did not appear to vary by gender and racial/ethnicity categories. In regards to the third research question guiding this study, the only high school experiences reported by this study to vary by gender and race/ethnicity were the number of science units. As mentioned earlier, women and men took over average the same number of science units, whereas Hispanic and African American students took fewer science units than their Asian and white counterparts.

Theoretical Contribution of STEM Major Choice Model

The design of the STEM major choice model in this study successfully incorporated student inputs and high school variables that are influential in choice of STEM major. These parameters indicate points in the STEM education circuit where intervention in terms of policy or practice may be introduced to attract students to the

STEM fields. While high school preparation, which is represented in this model as number of science units taken, impacts the choice of major, none of the variables representing math preparation, math self-efficacy or math performance proved statistically significant in this model. Given that success in math is often cited as the backbone of success in the STEM fields, variables representing math beliefs and experiences need refining to better represent high school experiences of community college students. For example, absolute number of math credits does not reflect the academic rigor or level of math taken. Often minority students are placed in lower tracks of math in high school, which may fulfill graduation requirements. Unfortunately, these courses may not prepare these students to meet the demands of math in STEM courses in college.

The postsecondary experiences included in the STEM major choice were not as successful in prediction of STEM major choice. This leads one to reconsider how community college students differ from students at 4-year institutions and what variables would best capture the college experiences that influence their entrance to the STEM fields. Although variables such as graduate degree aspiration are reported to have a positive effect on 4-year college students, the same effect is not seen for community college students. Perhaps refining education aspiration for community college students will better capture this parameter for the study model. For example, a student's education aspiration can be defined in terms of their goals upon entering college. A more relevant measure of education aspiration might be intention to transfer to a 4-year institution or complete an Associate's Degree. Intensity of attendance (full time or part-time) may also indicate commitment to educational goals (Horn et al., 2006).

The environment support variable of academic integration and financial aid as defined in this study were not significant factors for choice of STEM major. The measure representing academic integration did not reflect well the experiences of community college students on campus with faculty, advisors, and peers. An accurate measure of academic integration to community college needs to include variables, which better represent the types of interactions more common among commuter students. Studies report that academic integration occurs predominantly during in-class activities with peers and faculty (Karp, Hughes, & O'Gara, 2008). The variable of receipt of financial aid is perhaps too simplistic in its representation of how community college students finance their education and its impact on choice of STEM major. Community college may view financial aid as a financial burden instead of a supportive parameter.

Implications for Policy and Practice

Reduce gender gap. Gender inequality in participation in the STEM fields is an issue that is well documented in the literature (National Science Board, 2010; Turner & Bowen, 1999). Previous research found gender differences in STEM participation did not disappear when individual and background characteristics are equalized (Xie & Shauman, 2003). Gender differences are also not explained simply by differences in math and science achievement or high school course taking trends given that young women have essentially closed the gender gap in these areas (Riegle-Crumb, King, Grodsky, & Muller, 2012; Xie & Shauman, 2003). One point where there is a clear underrepresentation of women is their college major expectation at the end of high school. The gender gap at the point when students are formulating their intended college major may account for the deficiency of women in STEM fields (Xie & Shauman, 2003).

As another possible explanation, some researchers assert the American culture as does other Western nations encourages women to remain in educational and occupational sectors that avoid conflict with traditional gender roles. Even when women enter male-dominated professions, women tend to choose subfields that are consistent with their gender roles (Riegle-Crumb et al., 2012).

To tip the gender balance toward STEM major entrance, a holistic perspective must be adopted in which education policy and practice initiatives are coordinated between government, STEM professionals, higher education institutions, and primary/secondary schools. The federal government has taken steps to establish partnership between state governments and private organizations to develop programs that increase the presence of young women in the STEM fields. The Department of Education has funded, through competitive grants, over 90 school programs, which support girls and young women in the STEM fields by providing access to rigorous and stimulating academic preparation taught by highly qualified STEM teachers (White House, 2013). Programs such as these with validated success in STEM education should be supported and replicated in other schools. Partnership between federal agencies such as the National Aeronautics and Space Agency (NASA) and private organizations like Girl Scouts of America have a proven track record of providing venues for thousands of girls to learn about exciting STEM careers (White House, 2013). These types of partnership are needed to support and broaden the participation of girls in STEM fields. There are some case studies concerning STEM focused high schools, which indicate that very high percentages of young women in these specialized high schools continue their studies in STEM majors at college. While these schools are state funded, support does

come through other sources as federal grants, corporate donations, and local funding (Subotnik, Robert, Rickoff, & Almarode, 2010).

What can administrators and teachers in the K-12 segment of the STEM education circuit do to encourage the participation of girls and young women? Two strategies reported that influence the choice of STEM careers by young women are (a) envisaging themselves as STEM professionals in the future; (b) finding a meaningful connection between their future careers and their need to contribute to society and impact people's lives. Women consider the value of their potential career in the college major decision-making process (Lackland & De Lisi, 2001; Harris et al., 2009).

Introduction of girls and young women to a broad range of possible STEM careers early in their education and helping them understand the education pathways that are necessary to reach their goals will broaden their participation in the STEM fields. Some studies report that girls turn away from STEM careers as early as grades five and six (Ward, Miller, Sienkiewicz, & Antonucci, 2012). This trend makes it imperative that schools aggressively put in place programs that halt and reverse this trend. Career workshops targeting middle and high school girls are cited as one successful approach to stimulate interest in male dominated fields such as engineering or computer science. Workshops provide girls with specific career information, a safe environment to explore the field, and mentoring opportunities by female STEM professionals (Sinkele & Mupinga, 2011).

Interviews of girls found they are in interested in fields that help people, the environment, or animals, which tend to be linked with the biological sciences and not

physical sciences or engineering fields. Incorporation of inquiry-based activities incorporated into the school curriculum and out-of-school time (OST) learning programs are reportedly effective in helping girls making the connection. An addition of hands-on, inquiry-based activities designed to introduce STEM concepts to a traditional school science curriculum will assist girls in understanding how careers in science, engineering, and technology are involved in developing solutions for environmental and social problems (Little & Leon de la Barra, 2009). Programs that extend the science experience outside the classroom are often developed through a partnership between teachers and STEM professionals who are employed in the private sector or universities. Interacting with STEM professionals, using equipment or resources not normally available to classroom teachers, and working on socially relevant problems encourages girls to aspire and self-identify with STEM careers (Ward et al., 2012). The challenge of attracting young women to the STEM fields continues from primary/secondary schools into postsecondary institutions.

Community colleges already attract a large number of women to their doorsteps to pursue their postsecondary education. Whether these students enter with an interest in STEM or are yet to decide, strategies have been developed by outreach programs such CalWomen Tech Project (National Science Foundation Project) to attract them to STEM fields on community college campuses. These programs address the problem women have of visualizing themselves in the STEM workforce and of overcoming the stigma of some STEM fields such as computer science and technology as male dominated fields. CalWomen Tech Project boasts impressive increases in women in information technology programs in eight community colleges located in California. This particular

program uses an integrated approach which includes (a) outreach to students through marketing campaigns (videos, posters, career events, website) on campus featuring female STEM professionals; (b) intensive training of faculty and staff in recruitment and retention of women in STEM programs; (c) faculty training in curriculum and pedagogy styles supportive to women (National Science Foundation, 2012). Implementation of this type of comprehensive recruitment and retention strategy across many STEM programs available on community college campuses may help to erode the gender gap.

Classroom atmosphere and teaching methods in introductory STEM courses are factors which affect the entrance of women into science and engineering programs (Seymour & Hewitt, 1997). As of 2008, 83% of undergraduate faculties reported the use of the traditional lecture/discussion as their primary instruction method (Science and Engineering Indicators 2008). This statistic is particularly discouraging in light of over twenty years of NFS funding of research and development of new methods for undergraduate science education with special emphasis on how students actually learn disciplines like physics, mathematics, and chemistry. Current educational research reveals that an active learning approach or inquiry-based learning, where instructors and students explore topics in depth and apply the scientific principles and reasoning to real-life problems, result in a better learning experience and mastery of the discipline than the traditional one-way lecture (Brainard, 2007). Commitment to training current and future faculty in evidence-based teaching will go a long way to encouraging young women to enter the STEM fields at community college. Replacing standard lab courses with discovery-based research courses will stimulate excitement about solving real world problems and increase young women's identification as scientists. Although community

colleges have not traditionally promoted STEM undergraduate research by faculty and students, more institutions are finding funding or forming partnerships with 4-year institutions, private industries, or research institutes.

Promote STEM major choice among disadvantaged minority students. Regarding racial/ethnic differences, Hispanic and African American students lag behind their Asian and white counterparts in terms of entrance to the STEM fields. Their lower entrance numbers combined with higher attrition rates have contributed to their underrepresentation in the STEM workforce (Burk & Mattis, 2007). More comprehensive efforts are needed at the K-16 levels to prepare, inspire, and support these students as they traverse the STEM education pipeline. Important areas of attention, which are relevant to the entrance of underrepresented minorities to the STEM major include (a) academic preparation in K-12 education, (b) STEM mentors; (c) STEM career information; (d) undergraduate research opportunities.

Inequity in funding of school districts often puts minority students at a disadvantage in academic preparation (Museus et al., 2011). State and federal governments need policies in place that ensure low-income school districts receive sufficient funds to prepare students to succeed in the STEM fields. Partnering with STEM stakeholders such as private industries and foundations to supplement funding in high school districts is one avenue that could augment school budgets. Students aspiring to STEM college majors are often advised to take advanced placement (AP) STEM courses in high school. Unfortunately, not all students have access to these courses. Hispanic and African American students often attend high schools without the critical college prep courses such as calculus and trigonometry. These students typically have lower tracks of

math available in their high schools, which are insufficient to prepare them for study in STEM fields. Even when AP classes are available, Hispanic and African Americans tend to be underrepresented in AP courses. The problem of lack of rigorous preparation begins even before high school with many minority students already placed in lower levels of math and science in middle school. Students are behind in their math and science preparation even before entering high school.

All too often schools with the highest minority presence have the highest percentage of out-of-field teachers (i.e. not trained in the field) instructing students in STEM subjects (Hagedorn & Purnamasari, 2012). Having access to rigorous STEM courses taught by qualified STEM teachers, positively influences students learning and academic success in high school and beyond (Hagedorn & Purnamasari, 2012). Teacher qualifications have a direct effect on student learning. In light of the continued racial gaps in science and math achievement for minority students, the issue of finding and retaining qualified STEM teachers should be a priority for school districts (Scherer, 2003). Recruiting sufficient numbers of STEM teachers is a priority of the Obama administration with the cited goal of 100,000 STEM teachers in 10 years. State governments should also place STEM teacher training and recruitment as an integral part of their strategy to retain students in the STEM education pipeline. Attracting outstanding STEM students to the teaching profession by providing grants and financial aid to cover their postsecondary education costs should be a priority at the state and federal levels. STEM professionals who enter teaching as a second career are a potential source of teachers with an in-depth understanding of their discipline that is so critical for inspiring today’s students. Facilitation of their entrance to the teaching profession

through fast tracked teaching credentials will increase the pool of well-qualified STEM teachers.

Often minority students and their parents have limited knowledge of potential STEM occupations and educational demands required of a degree in STEM. Teachers and counselors are cited by students and parents as their primary choice of information when considering career options. Since less than 10% of school career counselors have STEM backgrounds and many science/math teachers have limited knowledge of STEM careers, schools need to provide resources and training to their staff and faculties to better prepare them for guiding their students toward STEM careers. Organizing programs where STEM professionals visit classrooms and share their educational and workplace experiences will give students more information on which to base their career decisions (Hall, Dickerson, Batts, Kauffman, & Bosse, 2011).

The close proximity of community colleges to local high school makes them the perfect partner to introduce minority students to STEM careers and bolster their academic preparation. Several nationally recognized STEM recruitment efforts in community colleges (Hagedorn & Purnamasari, 2012) have developed programs that allow students in grades ten through twelve to take college prep courses in technical areas such as engineering technology and information technology while receiving college credit. Other programs have focused on “at risk” minority students providing them with intensive counseling, summer programs, and research experiences with scientists (Cuyahoga Community College, 2010).

Stimulate early interest in STEM. Waning interest in the STEM fields even among students who are most proficient in math and science is a dominant issue connected to the maintenance of students in the STEM pipeline. Although this study measured interest of intended college major upon entering college, the development of interest in STEM field begins much earlier than the 12th grade of high school (Hurtado et al., 2009). Interviews of scientists and graduate students revealed the timing, source, and nature of their initial interest in science. The majority of students reported their interest in science began prior to middle school. For women, the first spark of interest usually stemmed from school or family initiated activities or support, whereas men's interest was initiated by their own activities or thoughts (Maltese & Tai, 2010). Remaining interviewees reported initial interest in science during middle school, high school, or college was associated with school based factors like the teacher, activities (lab, demonstrations, or projects), and curriculum content (Maltese & Tai, 2010). Inspiring and motivating students from that first spark of interest in the STEM fields through the rigors of STEM education is a daunting challenge, which will require curricular changes in K-12, professional development of STEM teachers, and development of bridges with STEM professionals and STEM college faculty.

Some of the discussion so far concerning women and minority students has focused on stimulating interest in STEM careers at an early age and sustaining that interest into postsecondary education. Students need the time and opportunities to recognize the connection between STEM subjects they study in the classroom and real world problems. There is not enough time within the structure of a normal K-12 classroom environment for students to master STEM skills, explore their application to

real world situations, and understand how this connects to STEM careers. Schools need to think outside of the box in the resource-strapped financial environments of most states. Schools must collaborate with interested STEM stakeholders such as museums, universities, and private industries to expand and support their STEM curriculum and train their STEM teachers.

Informal science education, which usually takes place outside the classroom has been shown to increase student interest and confidence in studying STEM fields. Informal science education can be incorporated in different forms. For example, sustained programs over years can be organized through science museums, zoos, and local universities and colleges with the added bonus of involvement of professional and academic scientists. Other programs may bring resources such as science kits or computer simulations into the classroom for a limited period of time. Often these programs have a built in teacher of professional development to assist in implementing engaging, inquiry based activities. Beyond the positive evaluations reported by these types of program, the majority of the funding comes from the federal government, corporate and private foundations, and the public (Thomasian, 2011).

Increased interest in STEM by K-12 students has been reported after participation in programs employing practices that are validated by research. These programs have content, which is based on real-world applications and includes hands-on learning, and STEM career information. Programs can range from one-day workshops for middle school students to summer internships for high school students. A variety of stakeholders including STEM professionals, universities, education foundations, and

private industries can be involved in these programs bringing expertise, funding, and community support to raise students' interest in STEM.

Current educational research reveals that an active learning approach or inquiry-based learning where instructors and students explore topics in depth and apply the scientific principles and reasoning to real-life problems result in a better learning experience and mastery of the discipline than the traditional one-way lecture, which is often the favored form of instruction in the STEM introductory courses in college (Brainard, 2007). Adoption of these teaching approaches in the introductory STEM courses in community colleges, along with replacing standard laboratory courses with discovery-based research courses, can assist in maintaining interest in STEM majors.

Expand high school science experiences. Results from this study indicate the number of science courses taken is important in supporting students as they travel through the STEM education pipeline. Increasing the number math and science courses taken by high school students in preparation for college and careers has been a priority of policymakers in response to the nation's STEM workforce crisis. Some efforts to achieve necessary changes in course-taking patterns have focused on graduation requirements for science and math. Graduation requirements have evolved over the past two decades starting with most states requiring 2 years in each subject during the mid-1980s. Gradually graduate requirements have strengthened in both science and math. For example, in 1987, only three states required 3 years of science to graduate high school. By 2008, more than half of the states (27) required 3 years of science (National Science Foundation, 2012). Even higher requirements were less common. The number of states requiring 4 years of science increased from 0 in 1987 to 4 in 2008. Science should mirror

the requirements of English in high school where over 90% of states require 4 years of English. Increasing the number of science courses may strengthen academic preparation, enhance student confidence, and maintain interest in the STEM fields (National Science Foundation, 2012).

Besides the number of science courses, education leaders and school counselors should focus on the rigor of science courses. Research suggests increasing the number of science credits may not be enough. Students should take more advanced courses, which include second year courses of subject such as advanced biology, chemistry, and physics.

An active learning approach or inquiry-based learning will enrich the science learning and experiences of high school students helping them to apply the scientific methods in solving relevant real-life problems (Brainard, 2007). Many studies report that an active learning or student-centered approach in the classroom fosters a better understanding of the scientific process and fundamental concepts of chemistry, physics, and other disciplines (Barr & Tagg, 1995). While there is literature support for the efficacy of this pedagogical method, most teachers model their teaching on experiences from undergraduate or graduate STEM courses where the majority of faculties use the traditional lecture/discussion as their primary instruction method (Science and Engineering Indicators 2008). Mastering inquiry-based pedagogy requires teachers to have the support of intensive professional development programs, time to practice, be able to internalize this type of teaching, and rely on peer support and resources. The commitment to implement high quality inquiry-based classroom and laboratory activities requires long-term commitment by teachers, their administrators, and agencies such as

the National Science Foundation, who develop and fund pilot programs using inquiry pedagogy for high school students.

Implications for Future Research

Expansion of the proposed model to include more relevant postsecondary experiences is needed to better understand the processes involved in STEM major choice by community college students. High school academic experiences included in this study are missing from the college component of the model. According to Bettinger (2010), the strength of a student's commitment to staying in the STEM circuit is reflected in the type of classes they take their very first semester at college. Students enrolled in 4-year institutions who took at least 63% of the credit hours in STEM courses the first semester, would eventually major in STEM, whereas students who only averaged 42% of their credit hours in STEM fields would eventually leave STEM majors (Bettinger, 2010) . The course-taking behavior of students is a more reliable indicator of their commitment to their major than their expressed interest or high school academic record (Bettinger, 2010). Thus, future research is encouraged to incorporate Postsecondary transcript data for ELS: 2002, which will be available in 2014. Exploration of course-taking patterns and STEM achievement will enhance the comprehensiveness of the STEM major choice model and provide more insight into the experiences of STEM majors at community colleges.

The mentoring relationship established between faculty and high school students who are low income, minority, or potential first generation college students while involved in summer research projects or in intensive academic STEM college prep have

been found to positively affect STEM major choice (Lam, Srivatsan, Doversplice, Vesalo, & Mawasha, 2005; Zhe et al., 2010). Currently, capturing these types of interactions is not possible with the available data in ELS: 2002. Future research is needed to include a third follow-up of the survey when it is available (eight years after completion of high school) and to examine the effects of undergraduate research and mentoring with the faculty. This will add another important dimension to academic integration measures for STEM students.

Refinement of the outcome variable beyond STEM and non-STEM categories may allow more customized policy and instructional practices for the different disciplines within the STEM field such as life sciences, physical sciences, engineering, or computer/technology fields. Given that participation in these fields varies by gender and race/ethnicity, capturing participation differences may reveal important insights into high school and college experiences in these specific fields.

Several variables, which were included in this study may merit revisiting and refining in a future study. For example, the variable representing the total units of math taken can be refined to reflect higher levels of math courses or more rigorous tracks of math such as number of AP courses. Researchers have found Algebra II is critical course for male career choices while 12^{th} grade calculus is positively correlated with enrollment of young women in science and engineering majors (Watt & Eccles, 2008). Using variables that capture enrollment in these courses may better define the effects of math curriculum on STEM major entrance. Perhaps incorporating SAT math scores would be a better proxy for math achievement than the 12^{th} grade math exam used in this study as SAT math scores are reported as influential in the literature. In the current study, none of

the postsecondary experiences, which are influential for students in 4-year institutions, were found to impact STEM major choice. For example, education aspiration, which is defined in this study as aspiring to a Bachelor's degree, may not be appropriate for this population of students. The immediate concern for many community college students is to transfer to a 4-year institution instead of degree completion. A better proxy for education aspiration for these students may be the intention to transfer to a 4-year institution or complete the Associate's degree. The environment supports incorporated in the study did not impact the STEM major decision for community college students. Researchers must rethink what these type of students need in terms of support. One suggestion would be to look at institutional characteristics such as percentage of minority students or faculties on campus to assess whether have effect on the presence of underrepresented minorities in the STEM fields. Further, more effort should be made to understand the institutional differences of community colleges and their effects on the education and career choices like college majors. Typical institutional characteristics of 4-year institutions such as selectivity, number of full time faculties, or research/teaching priorities are not applicable to community colleges. One researcher in STEM major choice area has suggested that differences in curricular focus are a more appropriate system to characterize these institutions (X. Wang, personal communication May 2013).

In this study, one-third of the community college students who enter college interested in STEM majors choose non-STEM majors. Understanding why these students changed their plans to enter the STEM fields will assist faculty and college administrators in planning intervention policies to prevent students from leaving the STEM education circuit. Since the gatekeeper introductory math and science courses are often barriers for

beginning STEM students, examining the course-taking patterns and grades might provide insight into their experiences in these courses. Given that many community college students are required to take remedial math courses, are these potential STEM majors discouraged as a result of prolonged time spent in remedial math courses? This group of students merit further study in order to reverse their defection to the non-STEM majors.

Finally, a comparison of the factors affecting the entrance of students to 4-year and 2-year institution merits further study in view of the fact that often distinct student populations attend these institutions. Community college students are more likely than students attending 4-year institutions to fall into the following categories: (a) minority; (b) low socioeconomic level; (c) female; (d) non-traditional age; (e) part-time status; (f) academically underprepared for college level work (Horn et al., 2006). The college major choice studies to-date have focused almost solely on students attending 4-year institutions so many of the parameters investigated are important for this specific population of students. While there will certainly be overlap of important factors influencing choice of STEM major for these two populations of students, there are reported differences in the strength of these parameters on choice of STEM major (Wang, 2013). Development of a model with parameters, which more accurately characterize these two populations of students, will provide educators and policymakers with a comprehensive understanding of their STEM major choice decision process. Insights gained will allow educators and policymakers to customize strategies for a specific population. Thus, a comparative analysis of these two populations of students is merited

to inform policymakers responsible for strengthening the STEM workforce (Dowd, 2008).

Meeting the economic challenges of the 21st century requires a robust, well-trained STEM workforce. Predictions from leaders across government, business, and STEM professions suggest the nation is not prepared to meet these challenges. The projected number for future STEM workforce is predicted to be insufficient for meeting the nation's economic needs. Recommendations from policy experts suggest part of the solution begins with the development of a diverse, academically prepared, and motivated population of STEM students who can successfully traverse the STEM education circuit and transition into the STEM workforce. Efforts are needed to provide STEM students with world class academic preparation and to maintain their interest over their entire education. Special attention is needed to encourage minorities and women to participate in the STEM education circuit and join the workforce so that the nation may benefit from their diverse perspectives on global problems. These students often have tremendous challenges and non-traditional pathways to achieve their STEM degrees. Educators and policymakers must assist and support these students as they pass through the STEM education circuit knowing their presence in the STEM workforce will invigorate our economy and improve the nation's ability to compete on the global stage.

References

Adelman, C. (1999). *Women and men of the engineering path: A model for the analysis of undergraduate careers*. Washington, D. C.: U.S. Department of Education.

Allison, P. (1999). *Multiple regression: A primer.* Thousand Oaks, CA: Sage.

American Association of Community Colleges. (2013, July 12). 2013 Community College Fast Facts. *American Association of Community Colleges*. Retrieved from http://www.aacc.nche.edu/AboutCC/Pages/fastfactsfactsheet.aspx

Anderson, E., & Dongbin, K. (2006). Increasing the success of minority students in science and technology. *American Council on Education*. Retrieved from http://www.acenet.edu/news-room/Documents/Increasing-the-Success-of-Minority-Students-in-Science-and-Technology-2006.pdf

Babco, E. (2007). *The STEM challenge: The role of the public workforce system in a national solution for a competitive science, technology, engineering, and mathematics (STEM) workforce.* Washington, D C: U. S. Department of Labor.

Bandura, A., & Adams, N. E. (1977). Analysis of self-efficacy theory of behavioral change. *Cognitive Therapy and Research*, *1*(4), 287-310.

Bandura, A. (1989). *Social foundations of though and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice-Hall.

Barr, R. B. & Tagg, J. (1995). From teaching to learning-A new paradigm for undergraduate education. *Change*, 27(6), 13-25.

Beede, D., Julian, T., Langdon, D., McKittrick, G., Khan, B., & Doms, M. (2011). *Women in STEM: A gender gap to innovation.* Office of the Chief Economist. Washington, DC: United States Department of Commerce.

Bettinger. (2010). To Be or Not to Be: Major Choices in Budding Scientists, Clotfelter (Ed.), *American Universities in a Global Market.* Chicago and London: The University of Chicago Press.

Betz, N. E., & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. *Journal of Vocational Behaviors, 23*, 329-345.

Boudarbat, B. (2008). Field of study choice by community college students in Canada. *Economics of Education Review, 27*, 79-93.

Brainard, S. G. & Carlin, L. (1998). A six-year longitudinal study of undergraduate women in engineering and science. *Journal of Engineering Education, 87*(4), 369-375.

Brainard, J. (2007) America's science test: the tough road to better science teaching. *The Chronicles of Higher Education*, 53 (48), A16.

Brown, D. (Ed.). (2002). *Career Choice and Development* (4th ed.). San Francisco, CA: Jossey-Bass.

Burk, R., & Mattis, M. (2007). *Women and minorities in science, technology, engineering and mathematics: Upping the numbers.* Northhampton. MA: Edward Elgar Publishing, Inc.

Business-Higher Education Forum. (2010). *Increasing number of STEM graduates: Insights from the U.S. STEM Education & Modeling Project.* Retrieved from http://www.bhef.com/solutions/documents/BHEF_STEM_Report.pdf

Chan, J. (2005). Faculty-student Interaction at the community college: a focus on students of color. *Research in Higher Education, 46*(7), 769-802.

Chen, X., & Weko, T. (2009). *Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education* (NCES 2009-161). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Clotfelter, T. C. (2010). *American Universities in a Global Market.* Chicago and London: The University of Chicago Press.

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

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

Cuyahoga Community College. (2010). *Upward bound math/science*. Retrieved from http://www.tric.edu/apply/hsstudents/upwardbound/Pages/UpwardBoundMathScience.aspx.

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

Day, J. C. (1996). *Population Projections of the United States by Age, Sex, Race, and Hispanic Origin: 1995 to 2050.* U.S. Bureau of the Census.

The Department of Commerce. (2012). *The competitiveness and Innovative Capacity of the United Statesd* . Washington, D.C.: The Department of Commerce.

Dickson, L. (2010, January). Major choices: race and gender differences in college major choice. The Annals of the American Academy of Political and Social Science, 627(1), 108-124.

Downey, J. P., McGaughey, R., & Roach, D. (2009). MIS versus Computer Science: An Empirical Comparison of the Influences on the Students' Choice of Major. *Journal of Information Systems Education, 20*(2), 357-368.

Freedman, E. (2011, May 26). Michigan two- and four-year colleges team up to boost minority STEM enrollment. *Diverse: Issues in Higher Education*, *28*(8), p. 11.

Frehill, L. M. (1997). Education and Occupational Sex Segregation: The Decision of Major in Engineering. *The Sociological Quarterly*, *38*(2), 225-249.

Gay, L. R., Mills, G. E., & Airasian, P. (2009). *Educational research: Competencies for analysis and applications.* Upper Saddle River, NJ: Pearson Education.

Goyette, K. A., & Mullen, A. L. (2006). Who Studies the Arts and Sciences? Social Background and the Choice and Consequences of Undergraduate Field of Study. *The Journal of Higher Education, 77*(3), 497-538.

Hagedorn, L. S., Maxwell, W., Rodriguez, P., Hocevar, D., & Fillpot, J. (2000). Peer and student faculty relations at community colleges. *Community College Journal of Research and Practice, 24*, 587-598.

Hagedorn, L., & Purnamasari, A. J. (2012). A realistic look at STEM and the role of community colleges. *Community College Review, 40*(2), 145-162.

Hall, C., Dickerson, J., Batts, D., Kauffman, P., & Bosse, M. (2011). Are we missing opportunities to encourage interest in STEM fields? *Journal of Technology Education, 23*(1), 32-46.

Harris, N., Cushman, P. S., & Anderson, R. D. (2009). Technology majors: Why are women absent? *The Journal of Computer Information Systems, 50*(2), 23-30.

Holland, J. L. (1959). A theory of vocational choice. *Journal of Counseling Psychology, 6*, 35-45.

Holland, J. L. (1997). *Making Vocational Changes.* Odessa, FL: PAR.

Horn, L., Neville, S., & Griffith, J. (2006). *Profile of Undergraduates in U.S. Postsecondary Education Institutions: 2003–04.* Washington, DC: National Center for Education Statistics.

Hurtado, S., Cabrera, N. L., Lin, M. H., Arellano, L., & Espinosa, L. L. (2009). Diversifying Science: Underrepresented Student. *Research in Higher Education, 50*, 189-219.

IBM Corporation. (2008). *American's Competitiveness: Hispanic Participation in Technology Careers Summit Report.* Palisades, NY: IBM Corporation. Retrieved from http://web.worldbank.org/WBSITE/EXTERNAL/EXTABOUTUS/0,,contentMDK:20653660~menuPK:72312~pagePK:51123644~piPK:329829~theSitePK:29708,00.html

Karp, M. M., Hughes, K. L., & O'Gara, L. (2008). *An exploration of Tinto's integration framework for community college students.* New York: Community College Research Center.

Kim, Y. K. (2010). Racially Different Patterns of Student-Faculty Interactions in College: A focus on levels, effects, and causal directions. *Journal of the Professoriate, 3*(2), 161-189.

Kim, Y. K., & Sax, L. J. (2011). Are the Effects of Student–Faculty Interaction Dependent on Academic Major? An Examination Using Multilevel Modeling. *Research in Higher Education, 52*, 589-615.

Krumboltz, J. D. (1979). Social learning and career decision making. In A. M. Mitchell, G. B. Jones, & J. D. Krumboltz, *A social learning theory of career decision making* (pp. 19-49). Cranston, RI: Carroll Press.

Lackland, A. C., & De Lisi, R. (2001). Students' choices of college majors that are gender traditional and nontraditional. *Journal of College Student Development, 48*(1), 39-48.

Lam, P. C., Srivatsan, T., Doversplice, D., Vesalo, J., & Mawasha, P. R. (2005). A ten-year assessment of the pre-engineering program for under-represented, low income and/or first generation college students at the University of Akron. *Journal of STEM Education*, *6*(3-4), 14-20.

Lee, J. D. (2002). More than ability: gender and personal relationship influence science and technology involvement. *Sociology of Education*, 349-373.

Lent, R. W., & Brown, S. D. (1996). Social cognitive approach to career development: An overview. *The Career Development Quarterly, 44*(4), 310-317.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice and performance. *Journal of vocational behavior*, *45*(1), 79-122.

Lent, R. W., Brown, S. D., & Larkin, K. C. (1984). Relation of self-efficacy expectations to academic achievement and persistence. *Journal of Counseling Psychology, 31*, 356-362.

Lent, R. W., Brown, S. D., Schmidt, J., Brenner, B., Lyons, H., & Treistman, D. (2003). Relation of Contextual Supports and Barriers to Choice Behavior in Engineering Majors: Test of Alternative Social Cognitive Models. *Journal of Counseling Psychology*, *50*, 458-465.

Leppel, K., Williams, M. L., & Waldauer, C. (2001). The Impact of Parental Occupation and Socioeconomic Status on Choice of College Major. *Journal of Family and Economic Issues, 22*(4), 373-394.

Leslie, L. L., McClure, G. T., & Oaxaca, R. L. (1998). Women and minorities in science and engineering. *The Journal of Higher Education, 68*(3), 239-276.

Leung, A. S., Ivey, D., & Suzuki, L. (1994). Factors affecting the career aspirations of Asian Americans. *Journal of Counseling and Development, 72*, 404-410.

Little, A. J., & Leon de la Barra, B. A. (2009). Attracting girls to science, engineering and technology: an Australian perspective. *European Journal of Engineering Education, 34*(5), 439-445.

Ma, Y. (2009). Family socioeconomic status, parental involvement, and college major choices - Gender, race/ethnic and nativity patterns. *Sociological Perspectives, 52*(2), 211-234.

Malcolm, L. E. (2010). Charting the pathways to STEM for Latina/o students: The role of community colleges. In E. R. Harper, & C. B. Newman (Eds.), *Students of color in STEM: Engineering a new research agenda* (pp. 29-40). San Francisco: Jossey-Bass.

Maltese, A. V., & Tai, R. H. (2010). Eyeballs in the fridge: Sources of early interest in science. *International Journal of Science Education, 32*(5), 669-685.

Maple, S. A., & Stage, F. K. (1991). Influences on the choice of math/science major by gender ethnicity. *American Educational Research Journal, 28*(1), 37-60.

McArthur, R. C. (2005). Faculty-based advising: An important factor in community college retention. *Community College Review,* (4), 1-19.

McInerney, C. R., Didonato, N. C., Giagnacova, R., & O'Donnell, A. M. (2006). Students' choice of information technology major and career: a qualitative study. *Information Technology, Learning, and Performance Journal, 24*(2), 35-53.

Mullin, C. M., & Phillippe, K. (2011, December). *Fall 2011: Estimated headcount enrollment and Pell grant trends.* Retrieved from American Association of Community Colleges: http://aacc.nche.edu/Publications/Reports/Documents/Headcount_Enrollment.pdf

Museus, S. D., Palmer, R. T., Davis, R. J., & Maramba, D. C. (2011). Racial and ethnic minority students' success in STEM education. *Association for the Study of Higher Education, Higher Education Report, 36*(6), 1-140.

National Academy of Science. (2010). Rising *Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*. Washington, DC: The National Academies Press.

National Center for Education Statistics. (2009). *The Nation's Report Card: Mathematics 2009 (NCES 2010-451).* Washington, DC: Institute of Education Statistics.

National Center for Education Statistics. (2013). *Education Longitudinal Study of 2002 (ELS:2002)*. Retrieved from http://nces.ed.gov/surveys/els2002/index.asp

NGA Center for Best Practices. (2011). *Using Community Colleges to Build a STEM-Skilled Workforce.* Washington, DC: National Governors Association.

National Research Council and National Academy of Engineering. (2012). *Community Colleges in the Evolving STEM Education Landscape: Summary of a Summit.* S. Olson and J.B. Labov, Rapporteurs. Planning Committee on Evolving Relationships and Dynamics between Two- and Four-Year Colleges, and Universities. Board on Higher Education and Workforce, Division on Policy and Global Affairs. Board on Life Sciences, Division on Earth and Life Studies. Board on Science Education, Teacher Advisory Council, Division of Behavioral and Social Sciences and Education. Engineering Education Program Office, National Academy of Engineering. Washington, DC: The National Academies Press.

National Science Board. (2010). *Science and engineering indicators 2010.* Arlington, VA: National Science Board.

National Science Foundation. (2007). *Rising Above the Storm: Report from the Committee on Prospering in the Global Economy of the 21st Century.* Washington, DC: National Academies Press.

National Science Foundation. (2012, April 6). *Discovery CalWomenTech scale up project: Proven tools attract women to STEM training programs*. Retrieved from https://www.nsf.gov/discoveries/disc_images.jsp?cntn_id=123752&org=NSF

Nauta, M. M., & Epperson, D. L. (2003). A longitudinal examination of the social-cognitive model applied to high school girls' choices of nontraditional college majors and aspirations. *Journal of Counseling Psychology, 50*(4), 448-457.

Nicholls, G. M., Wolfe, H., Besterfield-Sacre, M., Shuman, L. J., & Larpkiattaworn, S. (2007). A method for identifying variables for predicting STEM enrollment. *Journal of Engineering Education*, *96* (1), 33-42.

Nutting, A. W. (2008). Costs of attendance and the education programs of first-time community college students. *Economics of Education Review, 27*, 450-459.

Oakes, J. (1990). Opportunities, achievement, and choice: Women and minority students in science and mathematics. *Review of Research in Education*, *16*, 153-222.

Olson, S., & Labov, J. B. (2012). *Community Colleges in the Evolving STEM Education Landscape: Summary of a Summit.* Washington, DC: National Academies Press.

Osborne, J. W. (2008). *Best Practices in Quantitative Methods.* (J. W. Osborne, Ed.) Thousand Oaks, CA: Sage Publications, Inc.

Pascarella, E. T., & Terenzini, P. T. (2005). *How College Affects Students* (Vol. 2). San Francisco: Jossey Bass.

Patton, W., & McMahon, M. (Eds.). (2006). *Career Development and System Theory* (Vol. 2). Rotterdam, The Netherlands: Sense Publisher.

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

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

technology, engineering and mathematics. Washington, DC: Executive Office of the President of the United States.

Pulver, C. A., & Kelly, K. R. (2008). Incremental validity of the Myers-Briggs type indicator in predicting academic major selection of undecided university students. *Journal of Career Assessment*, *16*, 441-455.

Rask, K. N., & Bailey, E. M. (2002). Are faculty role models? Evidence from major choice in an undergraduate institution. *Research in Economic Education*, *33*(2), 99-124.

Riegle-Crumb, C., & King, B. (2010). Questioning a white male advantage in STEM: Examining disparities in college major by gender and race/ethnicity. *Educational Researcher*, *39*(9), 656-664.

Riegle-Crumb, C., King, B., Grodsky, E., & Muller, C. (2012). The more things change, the more they stay the same: Prior achievement fails to explain gender inequality in entry into STEM college majors over time. *American Educational Research Journal*, *49*(6), 1048-1073.

Rosenbaum, J. (2001). *College for all.* New York: Russell Sage Foundation.

Scherer, M. (Ed.). (2003). *Keeping good teachers.* Alexandria, VA: Association for Supervision and Curriculum Development.

Science and Engineering Indicators 2006. (2006). Retrieved from http://www.nsf.gov/statistics/seind06/c2/c2h.htm

Science and Engineering Indicators 2008. (2008). Retrieved from http://www.nsf.gov/statistics/seind08/toc.htm.

Scott, A. B., & Mallinckrodt, B. (2005, March). Parental emotional support, science self-efficacy, and choice of science major in undergraduate women. *The Career Development Quarterly, 53*(3), 263-273.

Scott, T. P., Tolson, H., & Huang, T.-Y. (2009, Summer). Predicting retention of mathematics and science majors. *Journal of College Admission*, *204*, 20-24.

Seymour, E., & Hewitt, N. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO: Westview Press.

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

Sinkele, C. N., & Mupinga, D. M. (2011). The effectiveness of engineering workshops in attracting females into engineering fields: A review of the literature. *The Clearing House, 84*, 37-42.

Slater, M. (2011). Financial aid, student background, and the choice of first-year college major. *Eastern Economic Journal, 37*, 321-343.

Song, C., & Glick, J. E. (2004). College attendance and choice of college majors among Asian-American students. *Social Science Quarterly, 85*(5), 1401-1421.

Staniec Ordovensky, J. F. (2004, Fall). The effects of race, sex, and expected returns on the choice of college major. *Eastern Economic Journal, 30*(4), 549-562.

Stanton, R. (2010). State high school graduation requirements and access to postsecondary education (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses Database. (*ATT 3390456*, 184).

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

Suresh, R. (2006-2007). The relationship between barrier courses and persistence in engineering. *Journal of College Student Retention, 8*(2), 215-239.

Thomasian, J. (2011). *The role of informal science in the state education agenda.* Washington DC: National Governors Association Center for Best Practices.

Thompson, M. D. (2001). Informal student-faculty interaction: Its relationship to education gains in science and mathematics among community college students. *Community College Review, 29*(1), 35-57.

Trusty, J. (2002, Fall). Effects of high school course-taking and other variables on choice of science and mathematics college majors. *Journal of Counseling and Development, 80*(4), 464-474.

Trusty, J., & Ng, K.-M. (2000). Longitudinal effects of achievement perceptions on choice of postsecondary major. *Journal of Vocational Behavior, 57*, 123-135.

Trusty, J., Ng, K., & Plata, M. (2000). Interaction effects of gender, SES, and race-ethnicity on postsecondary educational choices of U.S. students. *The Career Development Quarterly*, *49*(1), 49-59.

Trusty, J., Robinson, C. R., Plata, M., & Ng, K.-M. (2000). Effects of gender, socioeconomic status, and early academic performance on postsecondary educational choice. *Journal of Counseling and Development, 78*(4), 463-472.

Tsapogas, J. (2004). *The role of community college in the education of recent science and engineering graduates.* Arlington, VA: National Science Foundation.

Turner, S. E., & Bowen, W. G. (1999). Choice of major: The changing (unchanging) gender gap. *Industrial & Labor Relations Review, 52*(2), 289-313.

U. S. Department of Labor, Employment and Training Administration. (2007, April). *The STEM workforce challenge: the Role of the public workforce system in a national solution for a competitive science, technology, engineering, and mathematics (STEM) workforce.* Retrieved from http://www.doleta.gov/youth services/pdf/STEM_Report_4%2007.pdf

United States Department of Labor. (2010, December 3). *Occupation Outlook Handbook, 2010-2011 Edition*. Retrieved from http://www.bls.gov/oco/oco2003.htm

Wang, X. (2013), Why Students Choose STEM Majors: Motivation, High School Learning, and Postsecondary Context of Support. *American Educational Research Journal, 50*(5), 1081-1121.

Wang, X. (2013). Modeling entrance into STEM fields of study among students beginning at community colleges and four-year institutions. *Research in Higher Education, 54*, 664-692.

Ward, R. B., Miller, J. L., Sienkiewicz, F., & Antonucci, P. (2012). ITEAMS: Increasing the self-identification for girls and underserved youth in pursuing STEM careers. *Systemics, Cybernetics and Informatics, 10*(1), 95-99.

Ware, N. C., Steckler, J. L., & Leserman, J. (1985). Undergraduate women: Who Chooses a Science Major? *The Journal of Higher Education*, 73-84.

Watt, H. M., & Eccles, J. S. (Eds.). (2008). *Why so few women? Explaining gendered occupational outcomes in science, technology, engineering and mathematics fields.* Washington, DC: American Psychological Association.

White House. (2012, November 1). *Higher Education*. Retrieved from http://www.whitehouse.gov/issues/education/higher-education

White House. (2013). *Women and Girls in Science, Technology, Engineering, and Math (STEM).* Retrieved from www.whitehouse.gov/ostp/women

Xie, Y., & Shauman, K. A. (2003). *Women in Science Career Processes and Outcomes.* Cambridge, MA: Harvard University Press.

Zhe, J., Doverspike, D., Zhao, J., Lam, P., & Menzemer, C. (2010). High School Bridge Program: A multidisciplinary STEM Research Program. *Journal of STEM Education, 11*(1&2), 61-68.

Appendix A

Variables used in STEM major choice model

Variable name	Description	ELS variable label
Gender	Female = 2 Male = 1	F1SEX
Race	1= American Indian/Alaskan native 2= Asian, Hawaiian Pacific Islander 3= African American 4= Hispanic, no race 5= Hispanic race 6= more than one race non-Hispanic 7= white	F1RACE
Socioeconomic level	Composite variable of mother's education, father's education, family income, mother's occupation, and father's occupation	FSES1
12th grade math self-efficacy beliefs	Can do excellent job on math tests	F1S18A
	Can master math class skills	F1S18E
	Items based on 4-point Likert scales with 4 indicating almost always and 1 indicating almost never	
High school exposure to math and science courses	Units in mathematics Units in physical science Units in life sciences	F1R27_C F1R40_C F1R26_C
12th grade math achievement	High school senior math standardized score	F1TXMSTD
Interest in college major upon entering postsecondary education	Field of study respondent is most likely to purpose when beginning postsecondary institution STEM majors includes engineering, computer, information science, natural science, math, and environmental science	F2B15
Degree Aspiration	Highest degree respondent expects to complete	F2STEXP
Academic integration	Talk with faculty about academic	F2B18A

	matters outside of class Meet with advisor about academic plans Items based on 3-point scales with 3 indicating often and 1 indicating never	F2B17B
Financial aid receipt	Offered financial aid first year by first postsecondary institution	F2PS1AID
College readiness in math and science	High school math prepared for first postsecondary institution attended	F2B17A
	High school science prepared for first postsecondary institution attended Items based on 3-point Likert scales with 3 indicating great deal and 1 indicating not at all	F2B17B
College major	Declared major college in 2006 STEM majors include agriculture, biological sciences, computer, engineering, information sciences, math, statistics, physical science, and science technologies	F2MAJOR2

Appendix B

Recoding of variables used in STEM major choice model

Variable Name	Description	ELS variable label
Entrance into STEM fields of study	Respondent's 2006 major field of study is in STEM fields 1 = yes, 0 = no	Recoded from F2MAJOR2, STEM fields include agriculture, biological sciences, computer, information science, engineering, math, statistics, physical science, and science technology
Gender	Respondent's gender, female =1, male = 0	Recoded from F1SEX
Race/ethnicity		Recoded from F1RACE
African American	African American = 1, all other races = 0	
Hispanic	Hispanic = 1, all other races = 0	
Other races	American Indian, Alaskan native, more than one race = 1, all other races = 0	
White	White = 1, all other races = 0	
Socioeconomic status	Composite based on parent's education and occupation, family income	F1SES1 Continuous
Math testing efficacy high	almost always or often = 1, other responses = 0	Recoded from F1S18A
Math testing efficacy mid	Sometimes = 1, other responses = 0	
Math testing efficacy low (reference group)	Almost never = 1, other responses = 0	
Math class skills efficacy high	almost always or often = 1, other responses = 0	Recoded from F1S18C
Math class skills efficacy mid	Sometimes = 1, other responses = 0	
Math class skills efficacy low (reference group)	Almost never = 1, other responses = 0	
12^{th} grade math achievement	High school 12^{th} grade math exam score	F1TXMSTD
High school exposure to math courses	Units of math credits	F1R27_C
High school exposure to science courses	Generated by summing units of physical sciences and life sciences	F1R40_C + F1R26_C = units of science credits

Intended college major upon entering postsecondary education	Respondent's interest in STEM 1 = yes, 0 = no	Recoded from F2B15, STEM majors include engineering, computer, information science, natural science, math, and environmental science
Aspire to Bachelor's degree or higher	Respondent expects to earn Bachelor's degree or higher; 1 = yes, 0 = no	Recoded from F2STEXP
Interaction with faculty	Frequency of interactions Often or sometimes = 1 Never = 0	Recoded from F2B18A
Interaction with advisor	Frequency of interactions Often or sometimes = 1 Never = 0	Recoded from F2B17B
Financial aid receipt	Offered financial aid first year 1 = yes, 0 = no	Recoded from F2PS1AID
College readiness in math	High school math prepared for first postsecondary institution attended 1 = great deal 0 = somewhat or not at all	Recoded from F2B17A
College readiness in science	High school science prepared for first postsecondary institution attended 1 = great deal 0 = somewhat or not at all	Recoded from F2B17B