

COMMUNITY COLLEGE TRANSFER STUDENTS' SUCCESS IN STEM FIELDS OF
STUDY: THE IMPACT OF ENGAGEMENT ON BACCALAUREATE
DEGREE ATTAINMENT

by

Trang Van Dinh

DISSERTATION

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Supervising Committee:

Dr. Yi Leaf Zhang, Chair

Dr. Maria Adamuti-Trache

Dr. Taryn Ozuna Allen

Dr. James Hardy

ABSTRACT

This study focused on community college transfer students and sought to determine the extent to which their baccalaureate degree attainment in Science, Technology, Engineering, and Mathematics (STEM) fields of study can be predicted by their demographic characteristics, precollege academic preparation, and their engagement in a wide range of domains while in college. The study used data drawn from the Educational Longitudinal Study (ELS:2002) to examine the demographic background and college experiences of 1,761 community college transfer students.

Astin's (1993) theory of involvement, or the Input-Environment-Output (I-E-O) model, was adopted as the guiding theoretical framework. In this study, the input variables included background characteristics (i.e., gender, race/ethnicity, socioeconomic status (SES)) and precollege academic preparation (grade point average (GPA) in high school and high school preparation in math and science). The environmental variables consisted of students' 1) engagement with active learning experiences (i.e., using school library services for coursework and participation in the community-based project and the mentoring program); 2) interactions with faculty and advisors (i.e., talking with faculty about academic matters outside of class, meeting with advisor about academic plans, and research with faculty outside of program requirement); and 3) participation in enriching educational practices (i.e., internship, study abroad, culminating senior experience, and volunteer service). Finally, output (O) represented community college transfer students' degree attainment in STEM. Quantitative analyses, including descriptive statistics, *Chi-square* tests, independent samples *t*-tests, and sequential logistic regression, were conducted to analyze the data.

A sequential logistic regression model was used to examine the background

characteristics, precollege academic preparation, and college engagement variables that predict STEM baccalaureate attainment among community college transfer students. The results of this study suggest that the background and precollege characteristics, including race (being Asian) and high school GPA, and college engagement, including working on coursework at the library and participation in the community-based project, research project with faculty, and culminating senior experience were predictors of the baccalaureate degree attainment in STEM among community college transfer students.

It is imperative that higher education institutions including both community colleges and 4-year universities take efforts to 1) examine the experience of Asian students, 2) provide academic support and motivation to students with low academic performance in high school, and 3) create opportunities and promote students' participation in the community-based project, research with faculty, and culminating senior experience. In addition, future studies could investigate the following topics, including 1) the college experiences and STEM degree attainment of transfer students against those of native students at the 4-year institution, 2) the experience of community college transfer students with school library, the community-based project, the research opportunity with faculty, and culminating senior project through in depth qualitative inquiry, 3) the experience of a cohort of community college beginners, and 4) students' external demands and STEM choice.

DEDICATION

This dissertation study is dedicated to all students who have sought or are seeking to obtain a baccalaureate degree via a community-college transfer route. Your stories are highly valued. This work is also dedicated to my son, Don Q. Le, with love.

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TABLE OF CONTENTS

ABSTRACT	ii
DEDICATION	iv
ACKNOWLEDGEMENTS	v
TABLE OF CONTENTS	viii
LIST OF FIGURES	xi
LIST OF TABLES	xii
CHAPTER ONE: INTRODUCTION.....	13
Statement of the Problem.....	16
Purpose of the Study	18
Research Questions.....	18
Significance of the Study	22
CHAPTER TWO: LITERATURE REVIEW	26
Engagement and Student Success.....	26
Persistence.....	28
Liberal arts outcomes.....	31
Engagement of community college students	32
Community College Transfer Students.....	34
Background characteristics	34
Engagement among community college transfer students.....	36
Baccalaureate degree attainment among community college transfer students.....	38
Persistence and Baccalaureate Attainment in STEM.....	44
Persistence in STEM.....	44
Baccalaureate degree attainment in STEM.....	45

Community College Transfer Students in STEM	49
Background	49
Experience with coursework	50
Experience with advisors	51
Experience with faculty	52
Experience with research	53
Theoretical Framework	55
CHAPTER THREE: RESEARCH METHOD	64
Overview	64
Research Design	67
Database	68
Population and Sample	71
Variables	71
Dependent Variable	72
Independent Variables	72
Data Analysis Procedures	78
Comparative Analyses	80
Sequential Logistic Regression	81
Delimitations of the Study	86
Summary	86
CHAPTER FOUR: RESULTS	87
Overview	87
Results of Research Question 1	89

Descriptive Analysis of Community College Transfer Students	89
Results of Research Question 2	94
Results of <i>Chi</i> -square Tests.....	94
Results of the Independent Samples <i>t</i> -Tests.....	101
Results of Research Question 3	108
Results of Sequential Logistic Regression Analysis.....	110
Summary	117
CHAPTER FIVE: DISCUSSION AND RECOMMENDATIONS	119
Chapter Overview	119
Summary of the Study	119
Discussion of the Results	120
Recommendations for Policy and Practice	130
Recommendation for Future Research.....	136
Conclusion	139
REFERENCES	142
APPENDIX A: LIST OF VARIABLES AND RECODED VARIABLES	163

LIST OF FIGURES

Figure 1. Literature map 27

Figure 2. A conceptual model of community college transfer student's baccalaureate degree attainment in STEM..... 63

Figure 3. Analytical model of STEM baccalaureate degree attainment (sequential logistic regression)..... 84

LIST OF TABLES

Table 1. Summary of ELS:2002 Sample Size and Response Rates.....	70
Table 2. List of Variables Used for the Study	76
Table 3. Data Analysis	79
Table 4. Descriptive Analysis of Demographic Characteristics and Precollege Preparation of All Community College Transfers, STEM BA Completers, and STEM BA Non-Completers	90
Table 5. Results of <i>Chi</i> -square Test.....	96
Table 6. Results of Independent Sample <i>T</i> -test.....	103
Table 7. Results of Logistic Regression Analysis on STEM Baccalaureate Degree Attainment in Each Model	111

CHAPTER ONE: INTRODUCTION

Upon the subject of education, not presuming to dictate any plan or system respecting it, I can only say that I view it as the most important subject which we as a people can be engaged in.

Abraham Lincoln

A highly educated workforce in science, technology, engineering, and mathematics (STEM) is pivotal for a globally competitive knowledge and technology-intensive economy (National Science Board, 2014). For most of the 20th century, the United States (U.S.) assumed a leading role in the global STEM community. However, the U.S. has recently fallen behind many developed nations in the world for producing relatively low proportion of STEM university degrees conferred (National Science Board, 2016). Specifically, the U.S. conferred 32.5% of all first university degrees to students in science and engineering fields whereas Japan and China awarded 57.2% and 49.4 % of their total university degrees, respectively, to science and engineering students. Germany and Canada also produced a higher percentage of science and engineering bachelor's degree recipients, 34.8% and 35.7%, respectively, than did the U.S. In addition, between 2000 and 2012, while the number of science and engineering degrees awarded in China, Taiwan, Germany, Turkey, and Mexico at least doubled, it only increased in the U.S. by about 50% (NSB, 2016).

Not only does the U.S. lag behind some developed nations with respect to the proportion of STEM baccalaureate degree earned, but it also faces a shortage of qualified laborers in a number of STEM areas. A paper reported to the U.S. Department of Labor indicated that there has been a consistent unfilled demand for laborers with a bachelor's and master's degree across many STEM fields (Xue & Larson, 2015). Due to this shortage of a skilled domestic workforce, jobs in STEM-related fields are being outsourced at a higher rate than ever before. As a result, it is critical that U.S. education institutions adopt strategies to boost STEM participation, retention,

and graduation rate to fill available positions and decrease reliance on outsourcing overseas (Kuenzi, 2008; Peterson, Lastra-Anadon, Hanushek, & Woessmann, 2011).

Community colleges educate nearly 50 percent of all college graduates and have become an integral part of the U.S. educational system (National Student Clearinghouse Research Center, 2017). Community colleges were established in the early 20th century in response to a desire by university educators for more research time. Universities wanted to relegate the function of teaching freshman and sophomore-level classes to the 2-year junior colleges (Cohen, Brawer, & Kisker 2014; Townsend, 2001). Since its foundation, the community college has become instrumental in providing educational opportunities for the American public, promoting class mobility, and fostering the college graduation rate in American colleges and universities.

Community colleges serve an array of students possessing a wide range of academic abilities and characteristics by offering low tuition and implementing an open-access policy (Cohen et al., 2014; Grubb, 2013; Nora & Crisp, 2012). In the face of capacity constraints, along with more draconian admission criteria and rapid tuition increases at the 4-year educational system, community colleges with nonselective admission policies, convenient locations, and smaller class sizes have effectively provided accommodation for many students whose financial condition, personal circumstances, and/or academic preparation would not allow them to enroll directly at a 4-year institution or remain there for the entire four academic years (CCRC, 2015; Cohen et al., 2014). Not only do community colleges provide these students with options in career/technical education, remedial education, continuing education, and workforce development, a primary function of the community college system is feeding students into 4-year institutions at the junior level (Cohen et al., 2014; Townsend, 2001). Through vertical transfer, community colleges offer a critical avenue for baccalaureate degree attainment for underserved

students, many of whom are low-income, first-generation college students from racial/minority backgrounds (CCRC, 2015).

In addition, as the demand for STEM-related jobs increases, community colleges are playing a critical role in educating STEM students and strengthening the STEM workforce. For many underrepresented minorities (URMSs) and female students, community colleges chart the course to a STEM higher education and a STEM baccalaureate degree (Jackson & Laanan, 2011; Jackson, Starobin, & Laanan, 2013; Laanan, 2001; Starobin & Laanan, 2008; Tsapogas, 2004). In fact, community colleges are contributing more significantly to STEM education than ever before. Nearly half of all STEM graduates have completed at least one course at a community college at some point in their academic journeys (Mooney & Foley, 2011; NSF, 2016; Reyes, 2011). Furthermore, one in four recent bachelor's degree recipients in science and engineering attended a community college after high school before enrolling in a 4-year institution (NSB, 2016). This indicates that community colleges' transfer function contributes to increasing the rate of baccalaureate degree attainment in STEM.

Attainment of a baccalaureate degree in STEM fields of study has become of paramount importance due to an increasing number of STEM occupations that now require at least a bachelor's degree (Carnevale, Smith, & Strohl, 2010; Xue & Larson, 2015). Thus, to fulfill this requirement of the workforce and to regain the global leadership it once held in STEM enterprise, the U.S. needs to produce more STEM baccalaureate graduates. U.S. universities and colleges could achieve the STEM degree goal by extending every effort to cultivate STEM interest and to provide guidance and support to students matriculating at postsecondary institutions every year so that they will choose STEM and persist to obtain a STEM baccalaureate degree. In the last decade, limited data has been collected on the retention,

completion and graduation rates of STEM education for students transferring from community colleges to 4-year institutions.

Statement of the Problem

A skilled workforce in STEM helps guarantee U.S. prosperity and national security (NSB, 2010; Roberts, Breedlove, & Strode, 2016). However, the U.S. is falling behind many leading economies in the world in the adequate supply of STEM employees. According to NSB (2014),

For over a decade, [...] other nations, led by China, South Korea, and Brazil, have been increasing their innovation capacity by investing heavily in higher education and in R&D [research and development]. These investments are shifting the balance of the scientific and technological landscape as the Asia-Pacific region now perform a larger share of global R&D than the United States. (p. 19)

This disparity between the U.S. and other regions of the world raises concerns about the future of American STEM education and STEM workforce in the global competition.

A critical strategy to augment the size, caliber, and diversification of the STEM workforce in the U.S. involves encouraging community college students to transfer to and complete STEM baccalaureate-granting programs (Hagedorn & Purnamasari, 2012). Because half of the baccalaureate undergraduates begin their educations at community colleges, it is crucial to examine what factors contribute to their baccalaureate degree completion, particularly in STEM. Additionally, studying STEM baccalaureate degree completion is timely and warranted when an increasing number of STEM occupations now require at least a bachelor's credential (Carnevale et al., 2010; Xue & Larson, 2015). Student background and precollege characteristics along with college engagement, which represents time and effort students devote

to a broad array of academic and non-academic activities proven to be beneficial to their college outcomes, have been widely recognized to impact degree attainment among all undergraduate students (Arbona & Nora, 2007; Astin, 1984, 1993a, 1993b; Dowd, 2004; Flynn, 2014; Pascarella & Terenzini, 2005; Ryan, 2004; Terenzini & Pascarella, 1991; Svanum & Bigatti, 2009; Tinto, 1998). Nevertheless, research thus far has not explored the background characteristics and college engagement among community college transfer students in relationship to their baccalaureate degree attainment particularly in STEM fields of study. Consequently, it has remained unknown how background characteristics in conjunction with college engagement affect baccalaureate attainment in STEM among this population of students. Literature about transfer students thus far has only linked background and college engagement to transfer intention, STEM aspiration (Myers, Starobin, Chen, Baul, & Kollasch, 2015), college adjustment (Jackson & Laanan, 2015; Lopez & Jones, 2016), and socialization in STEM programs at 4-year institutions (Jackson & Lannan, 2015). The knowledge about transfer students' STEM aspiration, adjustment, and socialization is valuable, indeed; however, without uncovering the possible driving force behind successful STEM degree completion, problems related to an inadequate college-educated STEM workforce will remain unsolved. Thus, empirical studies are needed to advance the understanding of the relationship between student background and engagement and the actual degree attainment in STEM among community college transfer population. This dissertation study was designed and executed, therefore, to address the gap in the literature by examining the extent to which community college transfer students' precollege characteristics and level of college engagement are associated with their baccalaureate degree completion in STEM fields of study.

Purpose of the Study

The purpose of this study was to determine if the baccalaureate degree attainment in STEM fields of study for community college transfer students could be predicted by demographic characteristics, precollege academic experience, and engagement in a wide range of domains while in college.

Most of the literature on baccalaureate degree attainment in STEM has been conducted in the 4-year context without specifically addressing students who first enrolled at the community college then transferred to the 4-year institution (Baker & Finn, 2008; Gayles & Ampaw, 2014; Lubinski & Benbow, 2006; Ma, 2011; Tai, Liu, Maltese, & Fan, 2006). Because a significant proportion of STEM graduates are community colleges transfer students, it is pivotal to expand the knowledge regarding the experiences of this particular group of students as they navigate their educational pathways towards baccalaureate degree attainment. As a result, the current dissertation study aimed to broaden the understanding of 1) community college students' background; 2) their engagement in college; and 3) precollege characteristics and engagement factors associated with baccalaureate degree attainment in STEM (STEM BA attainment) among community college transfer students. This understanding could help higher education institutions design and implement policies to promote students' engagement in various domains that are conducive to their degree outcome, especially in STEM pursuits.

Research Questions

The study was guided by the following research questions:

RQ1: What are the demographic characteristics (i.e., gender, race/ethnicity, SES) and precollege academic preparation (i.e., high school GAP and high school preparation in math and science for postsecondary education) of all community college transfer students in the sample?

Additionally, what are the demographic characteristics and precollege academic preparation of students who obtained at least a baccalaureate degree in STEM (STEM BA completers) and those who did not earn a bachelor's degree in STEM (STEM BA non-completers)?

RQ2: Among community college transfers, to what extent do STEM BA completers differ from the STEM BA non-completers regarding their demographic characteristics (i.e., gender, race/ethnic, and SES), precollege academic preparation (i.e., high school GPA, high school preparation in math, and high school preparation in science for postsecondary education), and college engagement (i.e., working on coursework at the library, using the web to access school library for coursework, participation in the community-based project, participation in the mentoring program, talking with faculty about academic matters, meeting with the advisor about academic plans, doing research with faculty, doing an internship, participating in the study abroad program, having culminating senior experience, and participating in the volunteer service)?

RQ3: For community college transfer students, to what extent are their demographic characteristics (i.e., gender, race/ethnic, and SES), precollege academic preparation (i.e., high school GPA, high school preparation in math, and high school preparation in science for postsecondary education), and college engagement (i.e., working on coursework at the library, using the web to access school library for coursework, participation in the community-based project, participation in the mentoring program, talking with faculty about academic matters, meeting with the advisor about academic plans, doing research with faculty, doing an internship, participating in the study abroad program, having culminating senior experience, and participating in volunteer service) related to their STEM BA attainment?

Hypotheses

A hypothesis is offered for only RQ2 and RQ3 because the first research question is descriptive in nature.

RQ2: Among community college transfers, to what extent do STEM BA completers differ from the STEM BA non-completers regarding their demographic characteristics, precollege academic preparation, and college engagement?

H₀: Among community college students, there is no difference between STEM BA completers and STEM BA non-completers regarding their demographic characteristics, precollege academic preparation, and college engagement.

H₁: Among community college students, there is a difference between STEM BA completers and STEM BA non-completers in at least of one of the following areas: their demographic characteristics, precollege academic preparation, and college engagement.

RQ3: For community college transfer students, to what extent are their demographic characteristics, precollege academic preparation, and college engagement related to their STEM BA attainment?

H₀: For community college transfer students, there is no relationship between their demographic characteristics, precollege academic experience, college engagement and STEM BA attainment.

H₁: For community college transfer students, at least one of the independent variables has a relationship with their STEM BA attainment.

Methodology

This study employed a quantitative approach using data drawn from an Educational Longitudinal Study (ELS:2002) by the U.S. Department of Education's National Center for Education Statistics (NCES) to examine research questions addressed by the study. Descriptive

analyses were conducted to explore the background demographics, high school preparation, and postsecondary experiences of community college transfer students, STEM BA completers, and STEM BA non-completers. Next, STEM BA completers were compared with STEM BA non-completers with regard to their demographic characteristics, precollege preparation, and engagement on a wide range of domains. Lastly, a logistic regression analysis was performed to determine what factors were associated with baccalaureate degree attainment in STEM among community college transfer students.

Theoretical Framework

This dissertation adopted Astin's (1993b) theory of student involvement, or the Input-Environment-Output (I-E-O) model, as the guiding theoretical framework. This framework originated from a longitudinal study on dropouts, which concluded that students' level of involvement in various domains while in college contributed to their persistence (Astin, 1984). Astin's (1993b) theory of involvement was selected because this dissertation study sought to determine whether students' engagement in college influences their baccalaureate degree completion, specifically in STEM fields.

The I-E-O model consists of three major components. The *input* (I) in this model refers to demographic and other background characteristics that students bring to college. In this study, the input variables included gender, ethnicity, socioeconomic status (SES), high school GPA, and high school preparation in math and science for postsecondary education. *Environment* (E) variables in the model were students' engagement with a wide range of activities in college. In this study, students' engagement was measured by 11 variables, which were classified into three categories,

- i. Active learning experiences

- 1) working on coursework at the library,
 - 2) using the web to access school library for coursework,
 - 3) participation in the community-based project, and
 - 4) participation in the mentoring program,
- ii. Interactions with faculty and advisors
- 5) talking with faculty about academic matters outside of class,
 - 6) meeting with the advisor about academic plans, and
 - 7) research with faculty,
- iii. Enriching educational practices
- 8) participation in the internship program,
 - 9) participation in the study abroad program
 - 10) having culminating senior experience, and
 - 11) participation in the volunteer service.

This categorization of variables was determined based on consultation with previous literature on student engagement (Hedrick, Dizén, Collins, Evans, & Grayson, 2010; Ishitani & McKittrick, 2010; Kinzie & Kuh, 2004; Kuh, 2003, 2009; Laird & Kuh, 2005; Ward, Yates, & Song, 2009). Finally, *output* (O) captures students' characteristics after leaving colleges, such as degree attainment, college GPA, career goals, and religious or political views. In this study, the output variable was community college transfer students' degree attainment in STEM fields of study at the baccalaureate level or above.

Significance of the Study

This study extends knowledge on factors associated with baccalaureate degree attainment in STEM among community college transfer students. The study also examines the applicability

of the I-E-O model on a particular group of students, community college transfers, and a specific educational outcome, baccalaureate degree in STEM fields of study. By investigating the impact of college engagement, the study offers findings that provide higher education institutions with valuable insights into designing programs that foster student engagement through active participation in a wide variety of activities that have been documented to enhance students' educational experiences. In addition, focusing on community college transfers, many of whom are ethnic minorities or come from a socio-economically disadvantaged position, this study addresses issues associated with diversity and social equity in STEM education and workforce. As such, the study illuminates approaches higher education institutions could adopt to help diversify the pool of the STEM-skilled workforce. Finally, this study could inform transfer students, especially those with a STEM aspiration, about strategies they could employ to successfully navigate their academic journey toward graduation and beyond.

Definition of Terms

The following definitions indicate the meaning of the terms employed in this study:

Baccalaureate degree attainment: The completion of a 4-year degree within six years of enrollment.

Community college transfer students: According to Pascarella and Terenzini (2005), community college transfer students are “students seeking a bachelor’s degree who begin their college careers in a [2]-year public institution” (p. 381). In addition, Wang (2009) defined community college transfers as those who enrolled in a community college soon after high school graduation and eventually transferred to a 4-year institution. For the purpose of this study, community college transfer students are those who meet the following criteria, 1) their first postsecondary institution is a 2-year institution, and 2) they did

attend a 4-year institution somewhere in their academic journey.

Culminating senior experiences: These experiences requires students approaching the end of their college career to create a project that integrates and applies what they have learned. “The project might be a research paper, a performance, a portfolio of ‘best work’, or an exhibit of artwork” (Kuh, 2008, p. 11).

Engagement: The dedication of time and energy that students dedicate to various activities while attending college and the actions taken from the institution to foster involvement in such activities (Kuh, 2001, 2003, 2009).

ELS: Education Longitudinal Studies.

STEM: This study adopted NSF’s definition, according to which, STEM fields include not only mathematics, natural sciences, engineering, and computer and information sciences, but also social/behavioral sciences as psychology, economics, sociology, and political science (Green 2007).

Outline of Dissertation

This study sought to investigate the relationship between background characteristics along with college engagement of community college transfer students and their baccalaureate degree attainment in STEM fields of study. The study adopted Astin’s (1993b) theory of student engagement and intends to provide policymakers, administrators, faculty members, student affair professionals at both 2- and 4-year institutions, and community college transfer students with sound practices to promote students’ baccalaureate degree attainment in STEM. This dissertation comprises five chapters.

Chapter 1 provides an introduction and overview of the study as well as an understanding of the theoretical framework that guided the study. It also outlines a statement of the problem,

the significance of the study, research questions, and definition of terms to be adopted throughout the study.

Chapter 2 provides a review of literature germane to the study. First, it introduces literature pertaining to the role of engagement in student success in their undergraduate studies and engagement among community college students. Second, it examines research regarding community college transfer students in relationship to characteristics differentiating them from non-transfers, their engagement, and baccalaureate degree attainment. Third, it provides a synthesis of literature on persistence and degree attainment in STEM fields of study at the undergraduate level. Fourth, it specifically addresses community college transfer students in STEM. Finally, it introduces the theoretical framework adopted by the study.

Chapter 3 provides the methodological and analytical design of the study. It provides an overview of the data, the variables, and data analysis approach. Chapter 3 also addresses limitations and delimitations of the study.

Chapter 4 presents the results of the analyses laid out in the previous chapter.

Finally, chapter 5 concludes the dissertation with a discussion of the results along with implications for policy and practice, and recommendations for future research.

CHAPTER TWO: LITERATURE REVIEW

This chapter discusses literature germane to the study, which sought to explore the relationship between student background characteristics along with college engagement and baccalaureate degree attainment in STEM among community college transfer students. First, literature pertaining to the role of engagement in student success in their undergraduate studies, represented by grade point average (GPA), persistence, baccalaureate degree attainment, and liberal arts outcomes is presented. This section ends with a presentation on engagement of community college students. Second, research regarding community college transfer students' characteristics, their engagement, and baccalaureate degree attainment is examined. Third, literature on persistence and degree attainment in STEM at the undergraduate level is explored. Fourth, studies specifically addressing community college transfer students in STEM are addressed. Finally, the theoretical framework adopted by the study is introduced. A literature map highlighting important studies relevant to the current study is provided in Figure 1.

Engagement and Student Success

Student engagement represents the time and efforts students commit to activities that are empirically demonstrated to foster desired college outcomes, as well as actions taken on the institution's part to encourage students' participation in these activities (Kuh, 2001, 2003, 2009). Literature often ties baccalaureate degree attainment to student engagement. In fact, student engagement has been documented to positively influence students' academic success, measured by GPA, persistence, degree completion, and achievement of liberal arts outcomes.

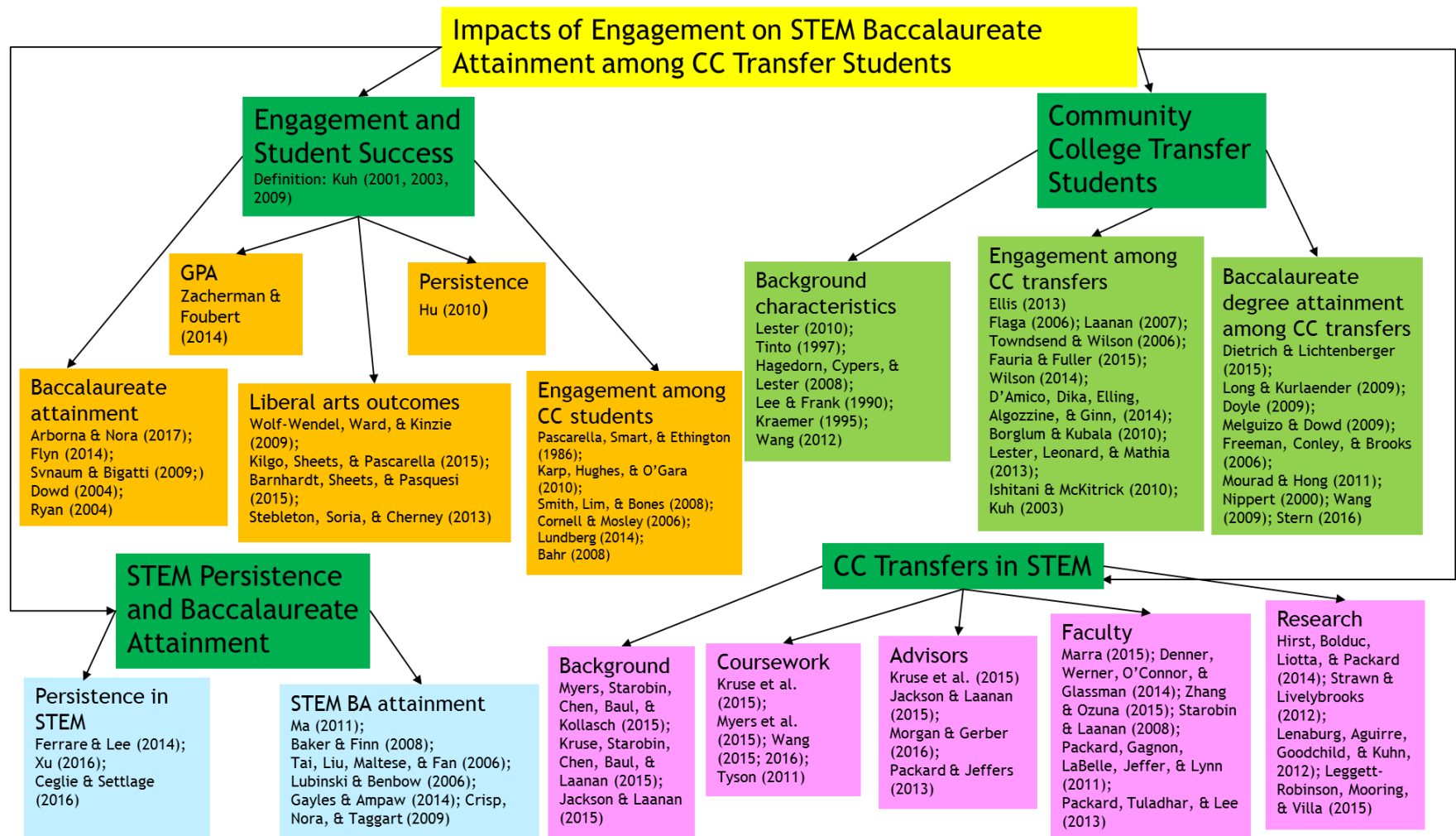


Figure 1 Literature map

Persistence. Employing data collected through two rounds of surveys of a cohort in the Washington State Achievers (WSA) program with a total sample size of 832, Hu (2010) sought to examine the relationship between student engagement activities and persistence in college. Persistence was determined by whether students continued to enroll at a postsecondary education institution when they were in their third year of college. Student engagement was divided into two factors: 1) academic engagement, which included working with other students, interaction with faculty, and working hard to exceed faculty expectations; and 2) social engagement, which consisted of participation in a wide variety of clubs and associations such as sororities or fraternities, residence hall activities, and cultural heritage-sponsored activities. Through logistic regression analysis, the study found that social engagement was positively related to persistence. On the other hand, the relationship between student academic engagement and persistence was found to be non-linear. Specifically, academic engagement, when not accompanied by social engagement, was negatively related to persistence.

Baccalaureate degree attainment. A substantial amount of empirical effort has been dedicated to investigate the connection between student engagement and baccalaureate degree attainment. While investigating degree completion, researchers considered several forms of engagement including 1) academic engagement (Arbona & Nora, 2007; Flynn, 2014; Svanum & Bigatti, 2009), such as engagement with coursework-related matters; 2) social engagement (Flynn, 2014; Dowd, 2004), such as participation in organizations and living arrangements; and 3) institutional factors, such as expenditures (Ryan, 2004).

Seeking to examine the effects of academic course engagement on college success, Svanum and Bigatti (2009) employed institutional data with the information of 225 undergraduate students enrolled in one upper division course. Academic course engagement was

defined as the amount of textbook reading and review that the student performed over the course of enrollment in the class, use of study guides, class attendance, and hours spent preparing for the exam. College success was determined by degree attainment, time spent on completing the degree, and college GPA. All of the information capturing academic success was obtained through transcript data. Results of the study demonstrated that students with higher level of academic course engagement were more likely to obtain a degree and complete the degree faster than those with lower level of course engagement. In addition, highly engaged students were found to achieve higher GPA's than expected, considering their mid-career GPA and college entrance exam scores.

Being in a rigorous academic path and showing commitment towards academic matters were also related to bachelor's degree attainment. Employing data drawn from the National Educational Longitudinal Study of 1988 (NELS:88-2000), Arbona and Nora (2007) explored factors associated with baccalaureate degree attainment among Hispanic students. The study had a sample size of 517 students who first enrolled at a community college and 408 students who began college at a 4-year institution. Using logistic regression analysis, the study suggested that for Hispanic students who started at a community college, their expectation to obtain a bachelor's degree, engagement in a rigorous academic trajectory, similarity to students attending a 4-year institution in terms of high school academic performance, and dedication to studies while at community college all displayed a significant positive relationship with college degree completion. On the other hand, for Hispanic students who enrolled directly at a 4-year institution, the key factors associated with baccalaureate degree attainment were parental education and having peers who planned to attend 4-year institutions.

While some researchers have primarily focused on academic engagement, others

demonstrate an interest in both academic and social engagement. Using data drawn from the 2004/09 Beginning Postsecondary Students Longitudinal Study (BPS:04/09) with a sample consisting of 8,700 students who began their studies in 4-year institutions, Flynn (2014) sought to understand the impact of academic and social engagement behaviors on persistence and degree attainment. In this study, academic engagement represented students' interaction with faculty, advisors, and study groups, while social engagement behaviors pointed to students' participation in school clubs, the fine arts, and sports activities. Utilizing logistic regression techniques, the study found that both academic and social engagement were associated with 4-year degree attainment.

In an earlier study on persistence and degree attainment, using data drawn from BPS:90/94 and a sample of 1,087 cases, Dowd (2004) found that the most important factors that positively associated with baccalaureate degree completion were living on campus and academic performance in the first year, measured by students' GPA. In addition, the acceptance of a state grant was reported as positively affecting persistence from the first to second year, while the receipt of a student loan was positively linked to degree completion.

Engagement does not only represent a commitment from students; it also reflects efforts from the institutions to motivate students to stay involved (Kuh, 2001, 2003, 2009). Expenditures is one such effort. Seeking to examine the relationship between institutional expenditures and students' degree attainment, Ryan (2004) adopted ordinary least-square (OLS) regression as a technique to analyze data from the Integrated Postsecondary Education Data System (IPEDS). The study included a sample of 363 institutions. Institutional expenditure was defined by the amount spent on various functional units as reported by institutions for the fiscal year of 1996. Findings of the study indicated that expenditures on instructional and academic support generate

a positive impact on degree completion rates. Academic support expenditures were defined as financial investment on “academic administration and curriculum development, libraries, audio/visual services, and technology support for instruction” (Ryan, 2004, p. 110).

Liberal arts outcomes. Liberal arts outcomes speak to outcomes associated with being a well-rounded citizen. Kilgo, Sheets, and Pascarella, (2015) defined liberal arts outcome as including these acquired skills: 1) critical thinking, 2) moral reasoning, 3) inclination to inquire and lifelong learning, 4) intercultural effectiveness, and 5) socially responsible leadership. Research has demonstrated evidence that college engagement benefited students’ liberal arts outcomes in several dimensions.

Wolf-Wendel, Ward, and Kinzie (2009) noted that engagement in academic and social activities in college could take multiple forms, including *high-impact educational practices*. These practices contribute to promoting student development and college outcomes (Kuh, 2008). Analyzing data of 4,193 undergraduate students at seventeen 4-year colleges and universities, Kilgo et al., (2015) found some evidence that high-impact practices did predict liberal arts educational outcomes. High-impact practices examined in the study comprised the following elements: 1) first-year seminars, 2) academic learning communities, 3) writing-intensive courses, 4) active and collaborative learning, 5) undergraduate research, 6) study abroad, 7) service learning and internship, and 8) capstone experience. Results of the study indicated that while *study- abroad* positively predicted intercultural effectiveness, *internship* positively influenced inclination to inquire and lifelong learning and socially-responsible leadership. Moreover, *capstone experience* was revealed to positively relate to inquire and lifelong learning. On the other hand, *service learning* was cited as negatively influencing inclination to inquire and lifelong learning, and *capstone experience* was found to negatively predict critical thinking.

Given the findings of these negative predictors on certain liberal arts area, the researchers suggested that “future studies should examine differences in administration and facilitation in order to determine how effective these practices truly are in educating students” (Kilgo et al., 2005, p. 522).

Additionally, student engagement in college was shown to positively influence civic commitment. In a mixed-method study using data drawn from the Personal and Social Responsibility Institutional Inventory (PSRI) and a sample of 9,710 cases, Barnhardt, Sheets, and Pasquesi (2015) sought to explore students’ civic commitments and skills as influenced by 1) their backgrounds in campus experiences—such as participation in a wide range of educational, co-curricular, and community activities, and 2) their perceptions on campus climate. In the study, *commitments and skills* acquisition was determined by students’ perceived level of growth in their commitment and skills to effectively exert positive changes to society. Results demonstrated that students’ attainments of commitments and skills for improving society were influenced by their perception of college campus as encouraging them to be active and involved students. In addition, *community-based projects*, when connected to a course, was found to be significantly impactful of students’ civic skills acquisition.

Finally, in a study administered to 99,810 undergraduate students across 12 large, public universities, Stebleton, Soria, and Cherney (2013) sought to explore the relationship between study abroad participation and college students’ development of global and intercultural competencies. Findings of the study revealed that participating in a study abroad program were positively associated with students’ understanding the complexities of global issues.

Engagement of community college students. A number of studies have linked student engagement to academic behavior and performance among community college students. For

example, in a study examining 825 students who initially enrolled at 85 community colleges, Pascarella, Smart, and Ethington (1986) found that academic and social integration was a positive predictor of persistence and completion. Similarly, in Karp, Hughes, and O'Gara's (2010) exploratory qualitative study, the majority of 46 participating students reported that integration in the college environment was associated with persistence. In the study, integration was defined as "having a sense of belonging on campus" (Karp et al., 2010, p. 75).

Engagement in the form of participation in first-year courses was also found to positively influence retention rate and academic behavior (O'Gara, Karp, & Hughes, 2009; Smith, Lim, & Bone, 2008). In a qualitative study with the participation of 44 community college students, O'Gara et al. (2009) revealed that students who took a student success course enjoyed their experience in the course and thought they obtained important skills necessary for academic success in college. Similarly, in a quasi-experimental study examining first-year community college students ($N = 736$), Smith et al. (2008) found that students who enrolled in the first-year experience course ($n = 341$) demonstrated significant gain in knowledge of campus resources and also displayed greater level of academic responsibility than their peers who did not enroll in the course ($n = 395$). In this study, academic responsibility referred to the "the skills and behaviors related to academic success in college" (Smith et al., 2008, p. 12).

Cornell and Mosley (2006) offered evidence that receiving advice from a peer-mentor, interaction with faculty, and support from advisors helps foster first-year students' integration into a community college environment. In addition, high frequency of interaction with faculty outside the classroom was shown to have the strongest impact on retention and persistence among 239 community college students (Lundberg, 2014). Moreover, a study using discrete-time event history analysis to analyze data of 202,484 California community college students found

that academic advising was beneficial to students' success, especially among the underprepared students (Bahr, 2008).

Community College Transfer Students

This section presents literature regarding the experiences of community college transfer students. First, it introduces the background characteristics of the students. Second, research on college engagement of community college transfer students is discussed. Finally, empirical studies on the baccalaureate degree attainment among community college transfer students are explored.

Background characteristics. When compared to students who started their postsecondary education at a 4-year institution, community college transfer students are generally portrayed as possessing distinctive characteristics. They are usually depicted as commuter students, working off-campus, coming from lower socioeconomic households, being first-generation college students, and assuming significant family responsibilities (Lester, Leonard, & Mathias, 2013; Office of Institutional Assessment, 2010; Tinto, 1997). In addition, the background characteristics of community college transfer students were usually revealed in studies that compared them to their community college non-transfer counterparts. When compared to non-transfer students, community college transfer students were found to 1) come from a family of higher socio-economic status (SES), 2) achieve a better high school academic outcome, 3) are more college ready, 4) enroll full-time, 5) perform academically better at the community college, 6) demonstrate an intention to transfer, and 7) hold higher educational aspiration (Hagedorn, Cypers, & Lester, 2008; Kraemer, 1995; Lee & Frank, 1990; Wang, 2012).

Using a sample of 2,500 students drawn from the High School and Beyond (HS&B) database, Lee and Frank (1990) designed a path diagram to investigate the student characteristics

that fostered transfer behavior. Their findings suggest that successful transfers were associated with coming from a high social class, being a white male, earning the highest test scores from high school, and possessing high educational aspiration (Lee & Frank, 1990). In addition, the researchers found that parental involvement in academic pursuits, enrollment in a math course in high school, and high school grades were all predictive of a student transferring to a 4-year institution.

In a study of 277 Hispanic students graduating from a junior college in Illinois, Kraemer (1995) found that the students' mathematics ability, academic performance, and intention to transfer to a 4-year institution after graduations were factors that significantly related to transfer. In this study, mathematic ability was measured by the score on the math placement test, which was taken at admission. Academic performance was represented by the students' cumulative grade-point average (GPA) at graduation.

In addition, utilizing a sample drawn from 5,000 students from the nine campuses of the Los Angeles Community College District (LACCD), Hagedorn et al. (2008) examined factors that influenced transfer for community college students. Using stepwise discriminant analysis to isolate factors that differentiate transfer students from their non-transfer counterparts, the study found that compared to non-transfers, transfers were younger, had higher English and math placement scores, had completed more transfer coursework, had passed 18% more courses, but did not come from a higher socioeconomic backgrounds. Readiness was found to be the most important differentiating factor. Specifically, students who transferred took courses that were "designated to open the transfer door" (Hagedorn et al., 2008, p. 660), and they were less likely to take remedial/developmental courses.

Employing data from the National Education Longitudinal Study of 1988

(NELS:88/2000) and the Postsecondary Education Transcript Study (PETS), Wang (2012) sought to identify factors associated with students' transfer to 4-year institutions among baccalaureate aspirants beginning at community colleges. Results of the study indicated that race/ethnicity and SES were both significantly related to upward transfer, with Blacks/African Americans and Hispanics being less likely to transfer than Whites. In addition, high school test scores positively predicted the probability of upward transfer. *Self-concept*, which represented the students' perception of themselves, was a marginally significant predictor of upward transfer. Regarding external demands, being married, being a parent, and working many hours all indicated a negative effect on upward transfer. Finally, *full-time enrollment* and *continuous enrollment* were both positive and significant predictors of upward transfer.

Engagement among community college transfer students. Previous research has offered ample evidence that engagement in college activities and the utilization of campus resources can greatly benefit community college transfer students (Ellis, 2013). In fact, students' academic and social engagement has been linked to students' successful transition and overall college experience (Flaga, 2006; Laanan, 2007). In a qualitative study of 35 community college students, Flaga (2006) defined *academic environment* as containing interactions with faculty, study groups, advisors, and seeking information on career opportunity. Flaga (2006) defined *social environment* as including interactions with other students through student organizations, parties, and residential housing. In addition, the researcher examined learning resources, which were defined as a wide range of facilities students utilized to obtain information about campus environment. The study indicated that *academic environment* and *social environment*, along with learning resources, all contributed to shaping community college students' transition experiences.

In a cross-sectional study that included 2,369 students transferring from California

Community Colleges to a Californian 4-year institution, Laanan (2007) identified several predictors of students' adjustment at the new institution. The study indicated that students who perceived faculty as approachable were more likely to have a positive adjustment experience. In addition, seeking counseling was positively related to adjustment. Moreover, students who were involved in clubs and organization were demonstrated to experience a smoother adjustment. On the other hand, meeting with advisors and spending time doing homework were shown to negatively affect adjustment. The researcher offered further explanation to such a negative relationship between the two factors: 1) meeting with advisors and 2) spending time doing homework, and students' acclimation at the 4-year institution: Students who paid more regular visits to advisors and spent more time doing homework might be the students who were struggling academically, hence, facing more difficulty in acclimating to the new environment.

Past literature also indicated that engagement with peer tutors, mentors, and academic advisors did, indeed, contribute to the enhancement of community college transfers' educational experience. Studying 346 students using hierarchical linear regression, Fauria and Fuller (2015) found that receiving tutoring from peers contributed to increasing GPA among community college transfers. Moreover, a qualitative study of 18 African American community college transfer students revealed that peer mentoring was conducive to transfer, transition, and degree attainment (Wilson, 2014). Meeting with advisors was also found to be positively related to an increase in second-semester GPA among community college transfers (D'Amico, Dika, Elling, Algozzine, & Ginn, 2014).

When compared to their peers who enrolled directly at a 4- year institution as freshmen, students transferring from community colleges were often cited as lacking engagement. Researchers found that transfer students who were academically integrated felt socially

integrated, although they demonstrated little interest in extracurricular activities and stayed on campus solely for attending classes (Borglum & Kubala, 2000; Lester, Leonard, & Mathia, 2013; Newell, 2014). Ishitani and McKittrick (2010) also confirmed this trend in a study surveying 118 community college transfers and 417 native students at a doctoral-intensive university. Specifically, the study found that compared to native students at the 4-year institution, community college transfer students were less engaged with 1) active and collaborative learning, which measured active involvement with the academic environment, 2) interaction with faculty, and 3) enriching educational experiences, which represented students' integration into diverse educational opportunities and institutional environments (Ishitani & McKittrick, 2010). Similarly, Kuh (2003) ranked transfer student engagement order from least engaged to most engaged as follows: 1) enriching educational experiences, 2) student-faculty interaction, 3) supportive campus environment, and 4) active and collaborative learning. These were also the four areas where transfer students were less engaged than native students at 4-year institutions (Kuh, 2003). A qualitative study conducted by Townsend and Wilson (2006) offered further explanation to this phenomenon: Community college transfer students perceived the 4-year institution as “an awkward fit” (p.450) due to its larger size classes, more research-oriented faculty, and less student-focused teaching.

Baccalaureate degree attainment among community college transfer students. There has been a large body of empirical works on baccalaureate degree attainment among community college students. Researchers of this topic often focus on examining the discrepancy in degree achievement between transfers and native students at the 4-year schools (Christie & Hutcheson, 2003; Dietrich & Lichtenberger, 2015; Doyle, 2009; Glass & Harrington, 2002; Lee, Mackie-Lewis, & Marks, 1993; Lichtenberger & Dietrich, 2013; Long & Kurlaender, 2009; Melguizo &

Dowd, 2009; Melguizo, Kienzl, & Alfonso, 2011; Monaghan & Attewell, 2014; Reynolds & DesJardins, 2009; Sandy, Gonzalez, & Hilmer, 2006). Scholars are also inquisitive about various factors associated with 4-year degree attainment among the transfer population (Freeman, Conley, & Brooks, 2006; Mourad & Hong, 2011; Nippert, 2000; Stern, 2016; Wang 2009).

Research pertaining to the impact of community colleges on students' baccalaureate degree attainment has shown mixed results. While a number of studies suggest no difference between community college beginning students and students starting out at 4-year institutions, other empirical works offer evidence about the inferior outcomes of the first group. In an attempt to test the “community college penalty” which refers to the assumption that students initially enrolling in community colleges are less likely to attain a baccalaureate degree than students who enroll directly in a 4-year institution, a number of studies have used propensity matching score to compare the educational outcome of these two groups of students. For example, using the data from the state of Illinois, Dietrich and Lichtenberger (2015) found that community college transfer students were just as likely to earn a bachelor’s degree as rising 4-year juniors at 4-year schools. These results are congruent with the findings of previous studies that found no disadvantage of community college transfer students in terms of 4-year degree attainment (Lee et al., 1993; Melguizo et al., 2011; Monaghan et al., 2014).

On the other hand, employing the data of Ohio public higher education system, Long and Kurlaender (2009) revealed that on average, students who initially entered higher education through community colleges appeared to lag behind students who entered via 4-year institutions. Specifically, community college transfer students were demonstrated to be 14.5% less likely to earn bachelor’s degrees within nine years. At the national level, Doyle (2009) used BPS:1996 data and came to a similar conclusion that community college attendance resulted in a lower rate

of baccalaureate degree attainment, “even when comparing two groups with identically distributed observable characteristics” (p. 203). This finding supports previous research about the detrimental effect of community colleges on baccalaureate degree attainment (e.g., Christie & Hutcheson, 2003; Dougherty, 1994; Reynolds & DesJardins, 2009; Sandy et al., 2006). However, through a different data analytical approach, researchers did find that the negative effect of being a community transfer could be diminished (Melguizo & Dowd, 2009).

Studying the effects of SES and institutional selectivity on baccalaureate completion, Melguizo and Dowd (2009) analyzed data drawn from NELS:88/2000 with the consideration of 250 community college transfer students and 790 rising juniors who enrolled directly at 4-year institutions after high school. The researchers demonstrated that the negative effect of being a transfer, as opposed to a junior who enrolled directly at a 4-year school, declined substantially after controlling for SES differences. The study also documented no statistically significant differences in undergraduate completion rates between low-SES transfer and low-SES rising juniors. In addition, the odds of completing the degree increases for students attending 4-year institutions with a higher level of selectivity.

Besides comparing the baccalaureate degree attainment between community college transfer students and students who enter higher education directly via 4-year institutions, researchers cast a wide net to capture factors associated with successful bachelor’s degree completion among community college transfers.

Scholars have been particularly interested in studying how certain risk factors impact baccalaureate degree attainment among community college transfer students (Freeman et al., 2006). These risk factors are: 1) delaying enrollment into higher education, 2) being a single parent, 3) being married, 4) having a dependent other than a spouse, 5) having no high school

diploma, 6) working full-time, and 7) being financially independent. Using BPS:96/01 with a sample size of 391 community college transfer students, Freeman et al. (2006) indicated that those with fewer risk factors were 1.3 times more likely to attain a baccalaureate degree. In addition, students who were 18 years old when they began their academic career were twice as likely to complete a baccalaureate degree. The study further demonstrated that rural residents in the sample were less likely to finish a baccalaureate degree. Moreover, students who continuously received Pell Grants attained baccalaureate degrees at a higher rate than those who did not.

Besides student background, college academic experiences were found to predict degree completion among community college transfers. Mourad and Hong (2011) conducted a study using institutional data of 1,106 students identified as community college transfers. The study found that the number of semesters enrolled at both the community college and 4-year institution, as well as credits earned and GPA at the community college, had a significant relationship with baccalaureate degree attainment. Baccalaureate completers were shown to spend fewer semesters at the community college than non-completers. Conversely, students who graduated with a bachelor's degree spent more time at 4-year institutions than those who did not earn the degree. In addition, both credits and GPA earned at the community college were shown to be positively related to baccalaureate degree attainment. Specifically, the more credits earned and the better GPA accomplished, the more likely the student graduated with a baccalaureate degree.

In another study, Nippert (2000) took both background characteristics and college experiences into consideration when examining baccalaureate attainment among community college transfers. Using data drawn from the 1986 and 1990 Cooperative Institutional Research

Program (CIRP) with a sample size of 626 students who began their postsecondary education at a 2-year college, Nippert (2000) sought to explore the relationship between students' backgrounds, college experiences, external influences, and institutional satisfaction on degree attainment among students entering high education via community colleges. In the study, four variables, including gender, parental income, high school academic record, and degree aspirations, represented students' background. College experiences and external influences consisted of college academic activities, college academic hours, college social hours, hours spent on personal activities, work status, marital status, and college GPA. Institutional satisfaction was measured by academic satisfaction, social satisfaction, and "choosing to re-enroll in freshman college" (Nippert, 2000, p. 32). Through multiple regression procedures, the researcher found six factors that emerged as significant predictors of students' degree attainment. They were gender, high school academic record, hours of employment, college academic activities, college GPA, and students' choosing to re-enroll in freshman college.

Similarly, Wang (2009) examined the influence of both precollege background characteristics and college experience factors on baccalaureate degree attainment among community college transfer students. The study used data drawn from NELS:88 and PETS with a sample size of 786 cases representing community college transfer students. Employing logistic regression as an analytical approach, the researcher found predictors of baccalaureate attainment among community college transfers included 1) being female, 2) coming from family of high SES, 3) having attended a high school that implements academic curriculum (as opposed to vocational curriculum), 4) GPA earned at the community college, 5) college involvement, and 6) not having to take remedial courses (Wang, 2009). In this study, college involvement included participation in any of the following activities: 1) performing arts, 2) college newspapers, 3)

student governments/politics, 4) social clubs, and 5) fraternities.

Finally, research demonstrated that the characteristics associated with both the student, such as 1) educational aspiration and 2) the institution—such as location and articulation agreement impact baccalaureate attainment among community college transfers. Employing two data sets, BPS:1996/2001 and IPEDS, with a sample of 1,424 community college beginners, Stern (2016) developed a two-level hierarchical linear model to identify predictors of transfer and baccalaureate degree attainment among community college students. The study found that students attending rural community colleges were more likely to transfer and obtain a bachelor's degree than students attending urban community colleges. On the other hand, while aspiration to obtain a bachelor's degree, age, and minority status were all found to significantly predict upward transfer, these factors did not display a significant relationship to baccalaureate degree attainment. The study did find a significant impact of articulation agreements on baccalaureate degree, although this factor exerts no influence on transfer. In the study, articulation was dichotomously coded “one for schools that are in states with comprehensive, statewide articulation agreements and zero for all other schools” (Stern, 2016, p. 358). Accordingly, students attending community colleges in states enforcing comprehensive, statewide articulation agreements were shown to be more likely to earn a bachelor's degree than those attending schools in states without such agreements.

Despite their substantial contributions to understanding factors associated with baccalaureate degree attainment among community college transfers, these empirical studies do not address the degree completion specifically in STEM fields of study. The unique characteristics that differentiate students who persist and subsequently graduate with a degree in STEM are explored in the next section of the literature review.

Persistence and Baccalaureate Attainment in STEM

Existing research on degree attainment and persistence offers a limited understanding of STEM students attending community college. Much of the scholarship on STEM education has focused on factors influencing STEM persistence and graduation in the context of 4-year institutions (Ceglie & Settlage, 2016; Ferrare & Lee, 2014; Griffith, 2010; Kokkelenberg & Sinha, 2010; Ost, 2010; Price, 2010; Rask, 2010; Seymour & Hewitt, 1997; Xu, 2015).

Persistence in STEM. To graduate with a bachelor's degree in STEM, students who declare a STEM major must first persist with their academic choice. In recent years, researchers have identified a number of key factors associated with student persistence in STEM. These factors include race, gender, SES, high school preparation, and the perception of college academic environment.

Demographic backgrounds and precollege experiences were found to influence students' decision to stay or depart from STEM programs. Using BPS:04/09 longitudinal data including 7,800 beginning bachelor's degree students, Ferrare and Lee (2014) examined factors predicting students switching in and out STEM fields of study. Overall, women were more likely than men to switch out of their original STEM majors and less likely to switch into STEM majors. The findings also suggest that ethnically, compared to White students, Black/African American and Hispanic students were more likely to leave STEM fields of study. Also, working more than 10 hours per week and paying a lower cost of attendance were associated with STEM students leaving STEM majors. In addition, STEM switchers came from family with lower SES, were less prepared to attend college and less socially and academically integrated into college life, and needed more financial support. In contrast, taking a calculus class in high school was a significant predictor of remaining in STEM. Achieving a high college GPA and frequently

engaging in study groups were also demonstrated to significantly correlate with students' persistence in STEM fields.

Besides demographics and precollege experience, perception of the college academic environment determined whether students remained in STEM. To gain deeper understanding of factors facilitating or hindering student persistence in STEM majors, Xu (2015) developed an online survey to accumulate responses from 702 students divided into two groups: STEM and non-STEM majors. Results of the study indicated that students were significantly less likely to depart from a STEM field of study if they held a positive perspective about class size, quality of teaching, and their overall academic program.

Perception about academic environment and institutional support is particularly important to women of color pursuing STEM careers. In a case study, Ceglie and Settlage (2016) explored student persistence in STEM of 16 women of color. Factors that emerged from the study as promoting minority women students' persistence in STEM studies were: 1) science preparation in high school, 2) faculty support, 3) the opportunity to engage in scientific research with faculty, 4) family support, and 5) religion. In addition, the majority of the participating students attributed their motivation to persist in STEM education to the altruistic nature of a career in science. They connected a career in STEM with the ability to "give back to the community" (Ceglie & Settlage, 2016, p. 182)

Baccalaureate degree attainment in STEM. The literature has documented a handful of factors related to baccalaureate degree attainment in STEM. These factors include: 1) gender; 2) high school academic preparation and performance in math and science; 3) early exposure to STEM careers; 4) interaction with faculty, advisors, and peers; 5) parental education and income; 6) postsecondary enrollment intensity (part-time/full-time); and 7) first-semester GPA.

Using data from ELS: 88-2000 with a sample of 4,036 bachelor's degree completers, Ma (2011) examined gender differences in STEM early interest, choice, and baccalaureate attainment and factors affiliated with STEM degree completion. Regarding early interest, the researcher found that men were almost three times more likely than women to intend to major in STEM during high school. In terms of STEM choice in college, however, a slightly higher proportion of female students chose to first major in STEM than did so in high school. In addition, with respect to degree completion, the study revealed that women and men had almost equal probability (approximately 0.3) from majoring in STEM to completing their STEM degree. Finally, the study suggests a positive correlation between math and science course-taking in high school and STEM degree completion.

Baker and Finn (2008) also found a positive relationship between high school math and science performance and STEM degree completion. While using NELS:88 data including 25,000 potential scholarship winners to investigate the relationship between receiving a nationally competitive scholarship and STEM degree completion, the researchers found that 60% of high-ability students, determined by SAT and ACT scores, earned a STEM bachelor's degree. Moreover, when high-ability was defined based on class rank, the number of math and science courses taken in high school, AP exam scores in STEM, and high school science fair awards, roughly 75% to 82% of the students completed STEM baccalaureate degrees. With regard to the effect for merit scholarships, results indicated that between 60% to 80% of recipients were already completing STEM degrees. The authors, therefore, concluded that merit scholarships would have a limited marginal effect on STEM degree attainment.

In addition to high school math and science achievements, results from studies conducted by Tai, Liu, Maltese and Fan (2006) and Lubinski and Benbow (2006) suggest that early

encouragement of and exposure to STEM careers are significant predictors of later STEM baccalaureate attainment. Using NELS:88 with a sample size of 12,144 participants, Tai et al. (2006) explored the predictability of science-related career aspiration among adolescent students on their actual STEM degree completion. Applying multinomial logistic regression, the researchers found that among bachelor's graduates, those who intended as 8th graders to pursue a science-related career were 1.9 times more likely to earn a baccalaureate degree in life science and 3.4 times more likely to complete a degree in physical science or engineering. Similarly, employing the Study of Mathematically Precocious Youth (SMPY) longitudinal study with 5,000 participants, Lubinski and Benbow (2006) examined students' characteristics associated with their sustained commitment to scientific endeavor. Specifically, participation in high school AP courses was shown to account for 5-7% of additional variance in STEM advanced degree attainment. Possessing mathematical gifts and higher spatial ability along with exhibiting high investigative-theoretical interest and lower social and religious interest were demonstrated to significantly correlate with persistence in STEM fields.

Closely related to the current dissertation study are two additional studies that examined the impact of both precollege and college experiences on baccalaureate degree attainment in STEM (Gayles & Ampaw, 2014; Crisp, Nora, & Taggart, 2009). Gayles and Ampaw (2014) employed data drawn from BPS:1996/2001 with a sample size of 1,488 students who entered college declaring a STEM major and who still remained in STEM in the last observed year. Adopting logistic regression analysis, the study found several factors to be positively associated with STEM degree attainment, which include 1) interaction with faculty and peers, 2) high school grades, 3) levels of parental education and income, and 4) attending full-time. Regular meetings with academic advisor, on the other hand, was reported as negatively impacting degree

completion, particularly for women. The study also revealed that females lagged behind their male counterparts with regard to degree attainment in STEM within a six-year span.

Studying a sample of 1,925 students who attended a Hispanic Serving Institution, Crisp et al. (2009) identified several background characteristics—precollege, college, and environmental factor—as predictors of STEM degree attainment. The study found that females were less likely than males to obtain a STEM degree. With regard to race/ethnicity, Asian Americans were found to be 2.48 times more likely to complete the degree than White students. Pertaining to precollege preparation, SAT math scores and high school percentile were identified to be positively associated with STEM degree attainment. With respect to college experience, the higher the first-semester GPA the student achieved, the more likely the student would attain the degree. While the study shed light on understanding the effects of both precollege characteristics and college experience on STEM degree attainment, it did not examine a wide range of college experiences, such as engagement with faculty and research opportunities. The study was also limited in scope in that it only examined one specific type of institution, whose student racial composition might not be representative of other types of 4-year environments.

The broad knowledge obtained from these empirical works regarding STEM baccalaureate degree attainment sets a foundation for understanding some unique characteristics and qualities of STEM aspirants and degree achievers. However, to date, topics related to STEM baccalaureate degree attainment among students beginning at community colleges has not been widely addressed. Students with similar career aspirations beginning postsecondary education at the community college might differ considerably from their peers who attend 4-year schools directly, as discussed in this section. Consequently, in recent years, researchers have started paying increasing attention to community college transfers who demonstrate aspiration to pursue

a STEM baccalaureate degree. Their diverse college experiences are beginning to be captured in the emerging body of literature.

Community College Transfer Students in STEM

The experiences community college transfer students or students in transfer track encounter in their journey toward baccalaureate degree in STEM could be classified into these categories: 1) background, 2) experience with coursework, 3) experience with advisors, 4) experience with faculty, and 5) experience with research. Mostly, scholars have demonstrated that these experiences contributed to transfer intention, STEM aspiration, adjustment at 4-year institution, and to some degree, persistence in STEM.

Background. Quantitative studies offer a primary understanding of background characteristics associated with community college students' aspiration to pursue a baccalaureate degree in STEM and their transfer and adjustment at the 4-year institution. For example, using large multiyear survey data with 5,140 cases, Myers, Starobin, Chen, Baul, and Kollasch (2015) indicated that among community college students, older students were 1.28 times more likely than younger students to aspire to pursue a 4-year STEM degree. Males were more likely than females to possess STEM aspirations. Students with more financial concerns, interestingly, were 1.12 times more likely to have STEM aspiration than those with less financial concerns. Those working few hours per week were more likely to intend to study STEM than those working frequently (Myer et al., 2015).

Additionally, Kruse, Starobin, Chen, Baul, and Laanan (2015) employed data with 5,140 participating students from 15 community colleges and a Structural Equation Model (SEM) to examine the interaction of social capital and financial constraints on students' pursuit of STEM degrees through transfer. The study identified parent education levels as a predictor of parent

involvement in high school, which, in turn, predicted students' intention to transfer to 4-year STEM programs. Students with financial concerns were shown to be less likely to have intention to transfer to the 4-year institution to earn a STEM baccalaureate degree.

Jackson and Laanan (2015) demonstrated the connection between some background characteristics and socialization and academic adjustment among community college transfer students. Investigating 320 students who had already transferred to a 4-year institution, the study found being male positively impacted academic adjustment among community college transfer students pursuing STEM education. By extension, female transfer students in STEM often encountered more difficulty in acclimating to the new academic environment than their male counterparts.

Despite providing some early understanding of the impact of gender, age, and some SES components on community college students' transfer decision, STEM choice, and adjustment at the 4-year institutions, current literature has not addressed the connection between such characteristics to STEM outcome, such as baccalaureate degree attainment in STEM among community college transfers.

Experience with coursework. Besides demographic backgrounds, students' course-taking behavior at the community college has been found to affect STEM aspiration, transfer intention, and STEM persistence. Students who completed more science and math courses were cited as more likely to have STEM transfer aspirations than students who completed fewer of those courses (Kruse et al., 2015; Myer et al., 2015). Students with transfer intentions were more likely to have STEM aspirations than those without transfer intention. Additionally, Wang (2016) analyzed 2,330 transfer student transcripts to examine the effects of science and math courses completed at the community college. This study revealed that if students earned more than 24

transferrable STEM credits, their probability of transfer in STEM increased to 21%.

Researchers also sought to compare the possibility of STEM baccalaureate attainment between transfer students and students beginning postsecondary education at 4-year institution with regard to course taking pattern. Studying 1,027 students who took science courses in Florida public institutions, Tyson (2011) determined that students who took prerequisite courses at the community college were as likely to complete engineering degrees as students who took those courses at a 4-year institution.

On the other hand, Wang (2015), using data drawn from BPS:04/09, offered quantitative evidence that students beginning at a community college were less likely to persist in STEM than their peers starting at 4-year institutions. In this study, STEM momentum, which represents the total attempted credit hours and the grade point in STEM courses students earned during the first two terms of enrollment in college, was identified as a key factor contributing to students' successful STEM degree attainment. Overall, the researcher found that students beginning postsecondary education at community colleges were less likely to graduate with a STEM degree than those starting at 4-year institutions. However, the study also suggests that the negative effect of beginning postsecondary education at the community college could be diminished, to some degree, if community colleges were able to influence students' academic behaviors, such as encouraging them to take many STEM courses early on and to earn high grades in them.

Experience with advisors. Both quantitative and qualitative data have demonstrated a relationship between advising and students' fruitful experience in their STEM pursuit. Kruse et al. (2015) found that community college advising has a significant impact on students' pursuit of STEM at 4-year institutions. In another quantitative study of community college transfer students, Jackson and Laanan (2015) substantiated the critical role of advisors in students'

smooth transition into 4-year STEM programs. Specifically, students who sought academic advisors' guidance regarding courses and career plans at the community college prior to transferring were more likely to have a positive adjustment experience once transferred. Besides advising, mentoring services were found to support student engagement in STEM among 375 baccalaureate aspirants who were attending community colleges (Morgan & Gerber, 2016).

Taking a qualitative approach with the representation of 82 community college students, Packard and Jeffers (2013) suggest that students benefited from advisors' knowledge about articulation agreements and financial aid opportunities at the 4-year program. On the other hand, the study also revealed that advisors' poor advising practice and lack of knowledge about transfer process led to delayed graduation and attainment of STEM baccalaureate degrees (Packard & Jeffers, 2013).

Experience with faculty. Besides advisors, faculty was identified as an important contributor to the intention to pursue STEM at 4-year universities among community college transfer students.

Studies using quantitative approach did find a significant relationship between engagement with faculty and student learning outcome in STEM fields. In a study with 436 transfer-bound students, Marra, Tsai, Bogue, and Pytel (2015) used exploratory factor analysis and multiple regression to reach a conclusion that student-faculty interaction is a significant predictor of engineering learning skills and commitment to engineering degree attainment. Similarly, studying 741 students taking computer and information sciences (CIS) courses at 15 community colleges, Denner, Werner, O'Connor, and Glassman (2014) identified instructor as a predictor of intention to pursue 4-year degree in CIS. For those who successfully transferred, Lopez and Jones's (2016) study of 280 students pursuing STEM suggest that the more interaction

they had with instructors outside class regarding academic matters, the more likely they were to acclimate in a university.

A litany of qualitative research has spoken to the importance of faculty to transfer students' academic experience in STEM programs. Exploring the experiences of 21 community college transfer engineering students, Zhang and Ozuna's (2015) qualitative phenomenological study indicates that community college instructors play a key role in encouraging students' professional growth and academic interests, especially in the field of engineering. In another study with the participation of seven female students, Jackson (2013) revealed that community college faculty and advisors provide significant guidance for female students to understand their STEM experiences and to better prepare for social and psychological adjustment in 4-year institutions. Starobin and Laanan (2008) also indicate that advising from faculty is important for female students to make the decision to transfer to a 4-year university and to pursue an engineering degree. Additionally, in a study of 22 female students who transferred and persisted with STEM, Packard, Gagnon, LaBelle, Jeffers, and Lynn (2011) found that female transfer students felt inspired by their community college professors, who they perceived as experienced, knowledgeable, patient, and caring. Furthermore, Packard, Tuladhar, and Lee (2013) surveyed 70 participants to explore the ways in which STEM faculty integrated transfer advising into their teaching practice. Results indicate that faculty at the community college make time and effort to convey information regarding transfer process as well as academic requirements at the 4-year school.

Experience with research. Prior studies have shown that engagement in research opportunities contributes greatly to community college students' motivation to pursue STEM baccalaureate degrees (Hirst, Bolduc, Liotta, & Packard, 2014; Strawn & Livelybrooks, 2012).

For instance, participation in a two-week residential summer bridge program at a research university helped students recognize resources needed for their academic success, enhanced their research experience, and promoted their interest in pursuing baccalaureate degree in STEM at a 4-year institution (Hirst et al., 2014; Lenaburg, Aguirre, Goodchild, & Kuhn, 2012).

In a longitudinal study with 141 participants, Lenaburg et al. (2012) found that the summer research opportunity at the 4-year institution helped students recognize resources needed for their academic success. In addition, participating students learned about the transfer process through consulting with peer mentors at the 4-year institution (Lenaburg et al., 2012). The majority (91%) of the students in the study reported that they gained confidence about transferring after participating in the program. In addition, 68% indicated that they were more inclined to pursue a STEM degree at a 4-year institution.

Using focus-group interviews with the participation of 12 students in STEM, Leggett-Robinson, Mooring, and Villa (2015) found that participants in research programs at 4-year institutions perceived the research experience as providing them with more knowledge of the field of study they aspired to pursue. Moreover, the participants developed a sense of belonging with the 4-year institution and experienced a decreased apprehension of the transfer process.

In examining the student data collected as part of the yearly evaluation process, Hirst, et al. (2014) found that 19 out of 28 community college students who participated in a summer research program at a 4-year institution did eventually transfer and graduate with STEM degrees. Qualitative data demonstrated that students commented on the growth from the research experience, with a focus on increased confidence and research skills, as important factors in their STEM persistence. Some of these students expressed an aspiration to pursue a graduate degree in STEM.

These recent studies about STEM transfer students and STEM transfer aspirants offer valuable insights into understanding the experiences the students encounter and various types of engagement they demonstrate throughout their educational pathways. However, little knowledge has been generated regarding the overall impact of these factors on baccalaureate degree attainment in STEM. Therefore, taking a quantitative approach and using longitudinal data that track students' progression, this current dissertation study sought to examine the predictability of these precollege characteristics and college engagement factors on the actual STEM degree completion among transfer students. In doing so, the study extends knowledge regarding community college transfers and the role of engagement in academic achievement in STEM fields of study.

Theoretical Framework

This dissertation adopted Astin's (1993b) theory of student involvement, or the Input-Environment-Output (I-E-O) model, as the guiding theoretical framework. This framework derived from a longitudinal study on college dropouts (Astin, 1984). Results of the longitudinal study suggest that students' participation in a wide range of activities and their interactions with various entities while in college contributed to their persistence (Astin, 1984). The I-E-O model hypothesizes relationships among three types of variables: 1) inputs, 2) environment, and 3) outputs.

The *input* (I) in this model "refers to those personal qualities the student brings initially to the education program" (Astin, 1993a, p. 18). In this study, the input variables included gender, race/ethnicity, socioeconomic status (SES), high school GPA, and the level of preparation on math and science in high school for postsecondary enrollment. *Environment* (E) variables represent "the student's actual experiences during the educational program" (Astin,

1993a, p.18). In this study, the engagement variables consisted of: the use of library service for coursework completion, community-based project, mentoring, interactions with faculty and advisors for academic matters, research with faculty, internship experience, study abroad, culminating senior experience, and volunteer service. Finally, *output* (O) captures ultimate skills or outcomes as students leave college, such as degree attainment, college GPA, career goals, and religious or political views. In this study, the output variable was community college transfer students' degree attainment in STEM fields of study at the baccalaureate level or above. The I-E-O model facilitates the investigation of the potential connection between students' precollege characteristics, college experiences, and final educational outcome. As a result, the model was suitable to examine the background, precollege academic preparation, and engagement in a wide range of domains among community college transfer students to determine what factors could be used to predict the achievement of a bachelor's degree in STEM.

The I-E-O model has been applied widely in the study of higher education. It was used to investigate the definition of success (York, Gibson, & Rankin, 2015), retention (e.g. Kelly, 1996), persistence (Heaney & Fisher, 2011), transfer intention and STEM aspiration (Myers et al., 2015), socialization experiences (Gardner & Barnes, 2007), sense of belonging (Johnson, 2012), and a wide range of educational outcomes such as graduation rates, GPA, and career choice (Geise, 2011) among college students. Researchers have also employed the framework as a guiding theory to examine degree completion among some specific racial groups such as African male students (Strayhorn, 2012) and Latino students (Martinez, 2012). However, the theory of student involvement, or the I-E-O model, has not been utilized to explore baccalaureate degree attainment in STEM fields of study, particularly among community college transfer students. Therefore, taking a quantitative approach, this dissertation study aimed to test the

model on a particular outcome, which is STEM baccalaureate attainment, and for a particular group of students, which is community college transfers.

Input

Gender: Ma (2011) indicates that men are almost three times more likely than women to intend to major in STEM during high school; at the baccalaureate attainment level, women are almost as likely as men to achieve the degree. On the other hand, other studies indicated that female students were less likely to persist and obtain a bachelor's degree in STEM than their male counterparts (Crisp et al., 2009; Ferrare & Lee, 2014; Gayles & Ampaw, 2014). Among community college students, male students are more likely to have STEM aspiration than female students (Myers et al., 2015).

Race/ethnicity: Prior research has consistently reported that at the 4-year institution, Black/African American and Hispanic students were less likely to persist and graduate with a bachelor's degree in STEM than were their White counterparts (Ferrare & Lee, 2014; Garcia & Hurtado, 2011; Koledoye, Joyner, & Slate, 2011). On the other hand, there is evidence that Asian students were more likely than White students to obtain a STEM baccalaureate degree (Crisp et al., 2009). Additionally, among community college beginners, Myers et al. (2015) found that Asian students were more likely to demonstrate intention to pursue a baccalaureate degree in STEM through vertical transfers than were their White counterparts.

SES: Past scholarships have indicated that for community college transfer students, coming from family with high SES increased the probability of their baccalaureate degree attainment (Nippert, 2000; Wang, 2009). Additionally, research on STEM students suggests that students of high SES background were more likely to persist and eventually graduated with a bachelor's degree in STEM (Ferrare & Lee, 2014; Gayles & Ampaw, 2014).

High school GPA: Results from previous research have shown that students' high school academic performance, including GPA, was positively related to their persistence in STEM (Baker & Finn, 2008; Gayles & Ampaw, 2014; Johnson, 2008).

Math and science preparation: Numerous extant literature has revealed a positive impact of high school math and science preparation on STEM baccalaureate degree attainment among students at 4-year institutions (Baker & Finn, 2008; Ceglie & Settlage, 2016; Lubinski & Benbow, 2006; Ma, 2011; Tai et al., 2006; Tyson, Lee, Borman, & Hanson, 2007). However, in a comparative analysis examining the experience of 1) students who enrolled higher education via a community college and 2) students who began at a 4-year institution, Wang (2013a) found that math and science college readiness exerted a stronger impact on STEM choice for the latter group than it did on the earlier group.

Environment

Using library resources for coursework: Engagement with coursework was identified as an important factor related to persistence in STEM (Ferrare & Lee, 2014). However, so far, no study has investigated the relationship between using library for coursework and STEM degree attainment. Moreover, Subramaniam, Ahn, Fleischmann, and Duin (2012) noted that "very few studies to date have examined the evolving roles of [...] library programs for STEM learning" (p. 170). In a rare study that focused on the utilization of library and STEM education, Kuh and Gonyea (2003) found that students majoring in math and science did not use the library as much as their peers in other disciplines do. In addition, the researchers indicate that transfer students made the least progress in information literacy (Kuh & Gonyea 2003).

Community-based project: According to Hunt, Bonham, and Jones (2011), community-based education, or service learning, "emphasizes a combination of active community

participation and ongoing reflection, sending learners out to serve in the community and then bringing them back to the classroom to reflect on their experiences and consolidate new insights” (p. 246). Participation in a community-based project was found to affect the acquisition of civic skills, one of the liberal arts outcomes (Barnhardt et al., 2015). For STEM students, being involved with community-based learning positively impacted their learning outcome. For example, a meta-analysis conducted by Springer, Stanne, and Donovan (1999) revealed that participation in the community-based project moved a student from the 50th percentile to the 70th on a standardized test. Additionally, Dochy, Segers, Van den Bossche, and Gijbels (2003) offered evidence that through community-based project participation, students may remember more of the acquired knowledge.

Mentoring: For students who began their postsecondary education at a community college, being mentored was found to foster academic integration, promote their transfer and transition experience, increase GPA, and contribute to baccalaureate degree attainment (Cornell & Mosley, 2006; Fauria & Fuller, 2015; Wilson, 2014). In addition, past research determined that mentorship in STEM courses facilitated STEM engagement and the aspiration to earn a bachelor’s degree in STEM fields for community college students (Lenaburg et al., 2012; Morgan & Gerber, 2016).

Interactions with faculty: Interactions with faculty are part of a positive experience for transfer students in STEM. Literature has shown that for transfer students, faculty guided them to navigate STEM and transfer pathways, supported them to acclimate at the 4-year program, and inspired them to pursue a STEM career (Denner et al., 2014; Jackson, 2013; Lopez & Jones, 2016; Packard et al., 2011; Marra et al., 2015; Zhang & Ozuna, 2015).

Meeting with advisors: While advisors were documented as beneficial to transfer students

pursuing STEM (Jackson & Laanan, 2015; Kruse et al., 2015; Packard & Jeffers, 2013), Gayles and Ampaw (2014) found that regularly meeting with an advisor was negatively related to STEM degree attainment among students at 4-years institutions. Packard et al. (2013) presented mixed results that advisors could both enable and jeopardize timely degree attainment in STEM.

Research with faculty: The benefits of undergraduate research participation have been well documented in extant literature examining the experiences of undergraduate students in general. These benefits include stronger interest in a discipline, heightening confidence and sense of belonging in an academic or professional community, improved technical or communications skills, higher retention rates, increased satisfaction with the undergraduate experience, and better preparation for graduate study (Bauer & Bennett, 2003; Ceglie & Settlege, 2016; Eagan et al., 2013; Hunter, Laursen, & Seymour, 2006; Kobulnicky & Dale, 2016; Lopatto, 2004; Russell, Hancock, & McCullough, 2007; Sadler, Burgin, McKinney, & Punjuan, 2010; Seymour, Hunter, Laursen, & DeAntoni, 2004). This research indicates that for community college students on transfer track, access to a research opportunity and being mentored by STEM faculty promote their STEM interest, encourage transfer behavior, enhance academic experience, and contribute to persistence and aspiration for graduate degrees (Hirst et al., 2014; Legget- Robinson et al., 2015; Lenaburg et al., 2012; Strawn & Livelybrooks, 2012).

Internship: Internship has been documented to be beneficial to the students' career prospect in STEM fields following graduation (Piper & Krehbiel, 2015). Also, through internship programs, employers receive opportunities to recruit and retain a trained STEM workforce prior to graduation (Gold, 2002; Jaeger, Eagan, & Writ, 2008). Xie (2014) also indicated that the students' overall interest in having a career in STEM increases 10% as a result of doing an internship. The quantitative study found that the majority of students who did an

internship reported an increase in work experience, discipline training, knowledge gain, and career awareness (Xie, 2014). For doctoral students in STEM, an internship could lead to the possibility of employment in higher education as new instructors (Gillian-Daniel & Waltz, 2016). In a qualitative study by Fifolt and Searby (2010), engineering students participating in an internship program considered the internship opportunity to be a very positive and enriching experience. The internship offered the students a support system to help them grow and advance in the field. On the other hand, Fifolt and Searby (2010) offered evidence of ineffective mentoring practice, reflected in the unclear communication of expectation from supervisor to supervisee and supervisors' lack of organizational skills to oversee students.

Study abroad: Stebleton, Soria, and Cherney (2013) noted the influence of study abroad participation to intercultural competency. Regarding the impact on STEM education, Roberts, Breedlove, and Strode (2016) offered some primary descriptive narrative about the benefits of participation in a study abroad program for students in a STEM track. The benefits include increased global experiences and foreign language skills. Additionally, the study abroad program “enable[s] students to contextualize internationalization in future educational and career opportunities” and “prepare[s] students to act with integrity, compassion, respect, equality, and diversity when interacting across cultures” (p. 229). Nevertheless, to date, little has been known regarding the effect of study abroad and persistence in STEM fields of study.

Culminating senior experience: The experience is designed to fulfill the needs for more in depth learning in the college curricular (Tickles, Li, & Walters, 2013). For some institutions, the course serves as an assessment instrument to determine whether the students are ready to transition from college to the next stage of their career (Carlson & Peterson, 1993; Gardner & Van der Veer, 1998; Murry, 1998). According to Thomas (2010), the culminating senior

experience facilitated students' inquiry, knowledge building and application, resolution, design, decision-making, and problem-solving skills. Eppes, Milanovic, and Sweitzer, (2012) suggest participation in a capstone course helped STEM students strengthen the following skills: 1) critical thinking, 2) quantitative reasoning, 3) teamwork, 4) communication, 5) information literacy, and 6) design processes.

Volunteer/community services: Gleason et al. (2010) offered some evidence that at the institutional level, community service projects promoted retention rate among STEM students.

Output

With longitudinal data that allow the tracking of students' progress through graduation, a few earlier studies offered some knowledge about students who obtained STEM baccalaureate degrees (Hirst et al., 2014; Packard et al., 2011; Wang, 2015). However, when examining the students who graduated, these studies only focused narrowly on three factors: 1) course-taking behavior (Wang, 2015), 2) having research experience at a 4-year institution (Hirst et al., 2014), and 3) exclusive experience of female students (Packard et al., 2011). This current dissertation study took a more holistic approach by investigating the impact of student background characteristics along with a host of engagement factors on transfer students' baccalaureate attainment in STEM.

Overall, Astin's (1993b) theory of involvement allows for the investigation of how students' demographic characteristics, precollege educational experiences, and college engagement influence their degree attainment in STEM fields of study. Figure 2 presented the conceptual model adopted by the study.

The next chapter presents a description of the methodological approach adopted for the study. Specifically, it provides an overview of the research questions, hypotheses, the database

used, sample, variables, data management, and analytical procedure. Delimitations and limitations are also addressed.



Figure 2. A conceptual model of community college transfer student's baccalaureate degree attainment in STEM

CHAPTER THREE: RESEARCH METHOD

Overview

The purpose of this study was to examine the baccalaureate degree attainment in STEM fields of study among community college transfer students. Specifically, this study sought to explore the demographic characteristics, precollege academic preparation, and college engagement factors that predict STEM bachelor's degree completion (hereafter STEM BA attainment) for community college transfer students.

The objective of this study was to determine if STEM BA attainment of study for community college transfer students is influenced by their 1) demographic characteristics, 2) precollege academic preparation, 3) engagement with active learning experiences, 4) interactions with faculty and advisors, and 5) participation in enriching educational practices.

The study employed data drawn from Educational Longitudinal Study (ELS:2002). The dependent variable of the study was students' attainment of at least a baccalaureate degree in STEM. The independent variables were selected according to the Input-Environment-Output, or I-E-O, model (Astin, 1993b). The *input* variables, which represent students' demographic characteristics (i.e., gender, race/ethnicity, and SES), and precollege academic preparation (i.e., high school GPA, the perceived level of high school math preparation, and the perceived level of high school science preparation for the first postsecondary institution). The *environment* variables highlighted students' college experiences and interactions with peers, faculty, and advisors, including: 1) active learning experiences (using library service to work on coursework, participation in the community-based project and the mentoring program), 2) interactions with faculty and advisors (frequency of interactions with faculty and advisors about academic matters, and participation in research project with faculty), and 3) enriching educational practices

(internship experience, participation in the study abroad program, culminating senior experience, and participation in the volunteer service). Finally, the *output* of the study was whether or not the students attained an undergraduate credential, or higher degree, in STEM, as defined by NSF (Green 2007).

This chapter describes the methodological approach adopted for the study. Specifically, it outlines the research questions, hypotheses, the database used, sample, variables, data management, and analytical procedure. The chapter concludes with the limitations and delimitations of the study.

Research Questions

The study was guided by the following research questions:

- RQ1: What are the demographic characteristics (i.e., gender, race/ethnicity, and SES) and precollege academic preparation (i.e., high school GAP, high school preparation in math, and high school preparation in science for postsecondary education) of all community college transfer students in the sample? Additionally, what are the demographic characteristics and precollege academic preparation of students who obtained at least a baccalaureate degree in STEM (STEM BA completers) and those who did not earn a bachelor's degree in STEM (STEM BA non-completers)?
- RQ2: Among community college transfers, to what extent do STEM BA completers differ from the STEM BA non-completers regarding their demographic characteristics (i.e., gender, race/ethnic, and SES), precollege academic preparation (i.e., high school GPA, high school preparation in math, and high school preparation in science for postsecondary education), and college engagement (i.e., working on coursework at the library, using the web to access school library for coursework, participation in the community-based

project, participation in the mentoring program, talking with faculty about academic matters, meeting with the advisor about academic plans, doing research with faculty, doing an internship, participating in the study abroad program, having culminating senior experience, and participating in volunteer service)?

RQ3: For community college transfer students, to what extent are their demographic characteristics (i.e., gender, race/ethnic, and SES), precollege academic preparation (i.e., high school GPA, high school preparation in math, and high school preparation in science for postsecondary education), and college engagement (i.e., working on coursework at the library, using the web to access school library for coursework, participation in the community-based project, participation in the mentoring program, talking with faculty about academic matters, meeting with the advisor about academic plans, doing research with faculty, doing an internship, participating in the study abroad program, having culminating senior experience, and participating in volunteer service) related to their STEM BA attainment?

Hypotheses

A hypothesis is only offered for RQ2 and RQ3 because the first research question is descriptive in nature.

RQ2: Among community college transfers, to what extent do STEM BA completers differ from the STEM BA non-completers regarding their demographic characteristics, precollege academic preparation, and college engagement?

H₀: Among community college students, there is no difference between STEM BA completers and STEM BA non-completers regarding their demographic characteristics, precollege academic preparation, and college engagement.

H₁: Among community college students, there is a difference between STEM BA completers and STEM BA non-completers on at least of one of the following areas: their demographic characteristics, precollege academic preparation, and college engagement?

RQ3: For community college transfer students, to what extent are their demographic characteristics, precollege academic preparation, and college engagement related to their attainment of at least a baccalaureate degree in STEM fields of study?

H₀: For community college transfer students, there is no relationship between any of the independent variables and STEM BA attainment.

H₁: For community college transfer students, at least one of the independent variables has a relationship with their STEM BA attainment.

Research Design

This study adopted quantitative research methodology and used the Input-Environment-Output (I-E-O) model as a guiding theory to examine the relationship between demographic background, precollege academic preparation, and college engagement on the baccalaureate degree attainment in STEM fields of study among community college transfer students. From the Educational Longitudinal Study (ELS:2002) data, six variables were selected to represent the *input* (I), or students' demographic background and precollege academic preparation (i.e., gender, race/ethnicity, SES, high school GPA, high school math preparation, and high school science preparation). In addition, 11 variables were selected from the data to represent the *Environment* (E), or student engagement in college. These engagement variables were divided into three categories, active learning experiences, interactions with faculty and advisor, and enriching educational practices. Finally, the *output* (O), or the educational outcome, was determined by whether or not the students obtain a degree in STEM fields of study at the

bachelor's level or above. Two variables were combined into one to create the outcome variable.

Database

Educational Longitudinal Study (ELS:2002) Data

For the purpose of this dissertation study, I employed data drawn from an Educational Longitudinal Study (ELS:2002) by the U.S. Department of Education's National Center for Education Statistics (NCES). ELS:2002 is a longitudinal, multilevel study that involved data collection from a wide range of respondents, including students, parents, teachers, school administrators, and librarians. ELS:2002 was first launched in the Spring of 2002 and was designed to monitor the progression of high school sophomores as they transitioned out of high school into postsecondary education and the workforce (Ingels et al., 2014). This longitudinal data set followed a nationally representative cohort of students beginning with their sophomore year (10th grade) in high school (the base year) and continued on with three subsequent follow-ups taking place in 2004 (12th grade), 2006, and 2012.

The sample in the base year (2002) consisted of 752 American high schools. In this base year, surveys were administered to students, their parents, principals, librarians, and administrators. The selection process that ELS:2002 utilized involved a two-stage, stratified sampling (Ingels et al., 2014). First, from a national list, 1,221 public, Catholic, and other private schools were randomly selected for participation. Of the eligible schools, 752 consented to participate in the study. Participating schools then provided enrollment lists of all sophomore students, of whom approximately 26 students per school were selected. Participants in the study were a nationally representative sample of White, Black/African American, Hispanic, Asian, American Indian, and multi-racial high school students at both public and private schools. In addition, non-public schools were oversampled to allow for comparison to public schools. Asian

students were also overrepresented compared to their White, Black/African American, and Hispanic counterparts to ensure an appropriate size for comparison to these groups (Ingels et al., 2014). In order for ELS:2002 to maintain a representative sample of high school seniors in the first follow-up in 2004 and to account for students who dropped out or completed high school early, seniors in 2004 who had not completed their sophomore year in 2002 were invited to participate in the study (Ingels et al., 2014).

The second follow-up was conducted in 2004 when most sample members were high school seniors (noting that some dropped out, some graduated early, and some were retained in previous grade) (Ingels et al., 2014). Participating students responded to the questionnaire, dropout questionnaire, and assessment in mathematics. Students who remained in the base-year school, transferred to a new school, completed high school early, or were homeschooled responded to different survey versions. In this round, a school administrator questionnaire was also administered. In addition, high school transcripts, including course taking records at the student level for grades 9-12 and a course offerings component, were collected in this follow-up.

In the second and third follow-ups, conducted in 2006 and 2012, respectively, transcript data were collected along with information regarding postsecondary entry and attainment, labor market, college experiences, and marital status. Specifically, the second follow-up focused on the following: 1) later educational and labor market activities of high school dropouts; 2) the transition of those who did not directly enter postsecondary education or to the workforce; and 3) access to and choice of higher education institutions among those who did enter postsecondary education. The third follow-up data bolstered further investigations of persistence in achieving postsecondary education goals, degree completion, barriers to persistence and educational attainment, impacts of educational indebtedness, entry into the workforce, social and economic

rate of return on education, and family formation and civic participation (Ingels et al., 2014).

The current study employed the first, second, and third follow-up survey information. The first follow-up (F1) provided information about students' demographic characteristics and precollege experiences. The second follow-up (F2) provided information regarding retrospective information about students' high school math and science preparation for college and college experiences, including interactions with faculty and advisors, use of library resources, and participation in the volunteer service. Finally, information collected in the last follow-up (F3) included involvement in internship, research, study abroad, community-based project, culminating senior experience, and mentoring programs, along with degree attainment.

Of the 17,591 students who were selected, 15,362 students (accounting for 87.3%) actually participated in the base year. For the first follow-up, 14,989 students out of 16,515 students selected (accounting for 90.8%) actually participated in the study. For the second follow-up, among 15,892 students selected, 14,159 students (accounting for 89.1%) voluntarily took part in the study. Finally, for the third follow-up, among 15,724 students selected, 13,250 students (accounting for 84.3%) participated in the study. Table 1 summarizes the sample size and response rates of ELS:2002.

Table 1

Summary of ELS:2002 Sample Size and Response Rates

Survey	Selected	Participated	Response Rate
Base year school	1,221	752	61.6%
Base year student	17,591	15,362	87.3%
First Follow-up	16,515	14,989	90.8%
Second Follow-up	15,892	14,159	89.1%
Third Follow-up	15,724	13,250	84.3%

SOURCE: U.S. Department of Education, National Center for Educational Statistics, Education Longitudinal Study of 2002 (ELS:2002).

Population and Sample

Among 16,197 cases in the ELS:2002 database, 4173 students (approximately 26%) enrolled at a 2-year institution as their first postsecondary institution. These students declared their sector of first known postsecondary institution to be a 2-year institution.

To define the target population of the study, the study used two variables: 1) sector of first known postsecondary institution (F3TZPS1SEC), and 2) ever attended a known 4-year institution (F3TZEVER4YR). The targeted population for this study was students who satisfied the following criteria: 1) their first known postsecondary institution is 2-year institution (F3TZPS1SEC=4 or F3TZPS1SEC=6), and 2) they did attend a known 4-year institution somewhere in their academic journey (F3TZEVER4YR=1). These students were defined as community college transfers. As a result, 1,761 cases were selected for the dataset of this study and are representative for the transfer student population at the national level.

Among these transfers, those whose transcripts showed that their highest degree attained as of June 2013 was a bachelor's or above (F3TZHIGHDEG=3, 5 or 7) and their degree was in STEM (F3TZSTEM2CRED=1 or 2) were identified as STEM baccalaureate degree completers. This study refers to this group as STEM BA completers. Those who did not meet the criteria are referred to as STEM BA non-completers, even if they may have completed a baccalaureate degree in other fields.

Variables

Adhering to the Theoretical Framework proposed for the study and previous literature on college student engagement, the study selected ELS:2002 variables that reflect students' demographic background and precollege academic experience along with variables representing students' engagement with active learning activities, interactions with faculty and advisors, and

participation in enriching educational practices while in college. Regarding the outcome variable, the study created a new variable on STEM baccalaureate degree attainment, which represented students' academic outcome.

Dependent Variable

Given the study's focus on baccalaureate degree attainment in STEM fields of study among community college transfer students, the dependent variable (STEM BA Attainment) described whether a community college transfer student obtained at least a baccalaureate degree in STEM by 2013. The dependent variable was created by crosstab two variables from transcript data: F3TZHIGHDEG, highest known degree attained as of June 2013, and F3TZSTEM2CRED, ever earned a postsecondary credential in a STEM field as of June 2013. STEM BA completers are those who achieved the following: 1) a bachelor's degree, or above, *and* 2) an undergraduate credential in a STEM field, or undergraduate and graduate credential or graduate only credential in a STEM field. Those who did not meet these conditions are defined as STEM BA non-completer (although they may have completed a baccalaureate degree in other fields). Accordingly, the dependent variable is dichotomous, where 1 means a student completed at least a bachelor's degree in STEM by 2013 and 0 otherwise.

Independent Variables

Demographic characteristics. Demographic variables, including gender, race/ethnicity, and socioeconomic status (SES) are available in the ELS:2002 dataset. Gender was dichotomously recoded ("0=male" and "1=female").

In the original data, race/ethnicity was coded as "1=American Indian/Alaska Native, non-Hispanic"; "2=Asian, Hawaii/Pac. Islander, non-Hispanic"; "3=Black or African American, non-Hispanic"; "4=Hispanic, no race specified"; "5=Hispanic, race specified"; "6=More than one

race, non-Hispanic”; and “7=White, non-Hispanic”.

In this study, two groups of Hispanic students were combined into one group. As the result, the variable was recoded as followed: “1=American Indian/Alaska Native, non-Hispanic”; “2=Asian, Hawaii/Pac. Islander, non-Hispanic”; “3=Black or African American, non-Hispanic”; “4=Hispanic, no race specified and race specified”; “5=More than one race, non-Hispanic”; and “6=White, non-Hispanic”.

SES was measured by SES quartile in 2004 when respondents were high school seniors: “1=lowest quartile”; “2=second quartile”; “3=third quartile”; and “4=highest quartile”. ELS imputed SES based on five equally weighted, standardized components: 1) father’s education, 2) mother’s education, 3) family income, 4) father’s occupation, and 5) mother’s occupation.

Precollege academic preparation. Students’ precollege academic preparation was measured by their GPAs for all courses they took in 9th and 10th grades and the level of high school preparation in math and science for college. Past research (Baker & Finn, 2008; Gayles & Ampaw, 2014; Johnson, 2008; Nippert, 2000; Tyson, Lee, Borman, & Hanson, 2007) documented the impact of high school GPA on persistence and baccalaureate degree attainment in STEM. In addition, previous literature (Baker & Finn, 2008; Ceglie & Settlage; 2016; Lubinski & Benbow, 2006; Ma, 2011; Tai et al., 2006; Wang, 2013a, 2013b) supported the impact of rigorous involvement in math and science courses in high school on college STEM interest, choice, and persistence.

High school GPA was coded as: “0=0.00 –1.00”; “1=1.01 – 1.50”; “2=1.51–2.00”; “3=2.01 – 2.50”; “4=2.51–3.00”; “5=3.01–3.50”; and “6=3.51– 4.00”. To solicit information regarding students’ preparation in math and science, two survey questions were designed to ask the students to what extend their 1) math courses and 2) science courses prepared them for first

postsecondary school. Students' responses were then coded as "1=not at all"; "2=somewhat"; and "3=a great deal" for both of the variables.

College engagement. The study divided college engagement into three types: 1) engagement in active learning experiences, 2) interactions with faculty and advisors, and 3) engagement in enriching educational practices. This categorization of variables was based on consultation with previous literature on student engagement (Hedrick, Dizén, Collins, Evans, & Grayson, 2010; Ishitani & McKittrick, 2010; Kinzie & Kuh, 2004; Kuh, 2003, 2009; Laird & Kuh, 2005; Ward, Yates, & Song, 2009). This grouping of the variables examined aligns closely with the benchmarks that both the National Survey of Student Engagement (NSSE) and the Community College Survey of Student Engagement (CCSSE) developed to assess various aspects of student engagement and institutional response. These two instruments have been rigorously examined and validated and have had a widespread use to investigate student engagement (Kuh, 2009). The structure of NSSE survey makes it "relevant to mission- or context-specific issues" (Kuh, 2009, p. 12) and convenient for use "immediately by faculty and staff to improve the undergraduate experience" (p. 7).

Constrained by the information available in ELS:2002, this study could not examine institutional performance, which is part of students' college experience (Astin, 1993b; Kuh, 2003). Therefore, the study only investigated three benchmarks related to individual student engagement. Accordingly, active and collaborative learning "measures the level of involvement in learning in different settings as well as collaborating with others" (Hedrick et al., 2010, p. 130); interactions with faculty and advisors capture the amount of learning resulting from students' interactions with faculty and advisors about academic matters; and enriching educational experiences measure "the amount of complementary learning opportunities in and

out of class augmenting academic programs and having diverse set of experiences to integrate and apply knowledge” (Hedrick et al., 2010, p. 130).

Active Learning Experiences. Engagement in active learning experiences represents students’ engagement in various settings as well as collaboration with other students (Hedrick et al., 2010). These variables included 1) working on coursework at the library, 2) using the web to access the school library for coursework, 3) community-based project, and 4) mentoring – which refers to students’ participation in a program in which they are mentored.

Variables pertaining to working on coursework at the library and using the web to access school library for coursework were measured on a 3-point Likert scale of “1=never”; “2=sometimes;” and “3=often”. These variables capture students’ experience at the first postsecondary institution, which, in this case, is the community college. Variables community-based project and mentoring were dichotomously coded, “0=no” and “1=yes” and reflect the students’ experience while attending pursuing postsecondary education in general.

Interactions with faculty and advisors. This engagement category represents the amount of learning occurred as a result of interacting with faculty members both inside and outside the classroom (Hedrick et al., 2010). Variables under this category included talking with faculty about academic matters outside of class, meeting with advisors about academic plans, and research project with faculty members outside course/program assignment.

Variables pertaining to talking with faculty about academic matters outside of class and meeting with advisors about academic plan were measured on a 3-point Likert scale of “1=never”; “2=sometimes;” and “3=often”. These variables represented students’ experiences in the first community college that they attended. The variable on research project with faculty member outside course/program assignment was dichotomously coded, “0=no” and “1=yes” and

measure a general college engagement.

Enriching educational practices. Enriching educational practices measure the amount of learning opportunities in and out of academic programs and contain a set of experiences contributing to knowledge integration and application (Hedrick et al., 2010). Enriching educational practices in this study are represented by students' participation in internship, study abroad program, and culminating senior experience (dichotomous variables), and the volunteer service. For students' participation in the volunteer service, a variable on the frequency of volunteer service was used and recoded as "0=no volunteer service"; "1=less than once a month"; "2=at least once a month but not weekly", "3=at least once a week".

Table 2 presents the independent and dependent variables used in this study. Additionally, the comprehensive list of original variables and the recoded variables along with the corresponding survey items on engagement variables can be found in Appendix A.

Table 2

List of Variables Used for the Study

Variable Name	Variable Description	Measure
Independent Variables:		
Background characteristics		
<i>Demographics</i>		
F1RACE	Students' race/ethnicity	1=Amer.Indian/Alaska Native, non-Hispanic 2=Asian, Hawaii/Pac. Islander, non-Hispanic 3=Black or African American, non-Hispanic 4=Hispanic 5=More than one race, non-Hispanic 6=White, non-Hispanic
F1SEX	Students' sex	0=Male 1=Female

(Continued)

Table 2 (Continued)

Variable Name	Variable Description	Measure
F1SES1QU	Quartile coding of SES1 variable	1=Lowest quartile 2=Second quartile 3=Third quartile; 4=Highest quartile
<i>Precollege academic experiences</i>		
F1RGPP2	GPA for all courses 9 th -10 th grade	0=0.00 – 1.00 1=1.01 – 1.50 2=1.51 – 2.00 3=2.01 – 2.50 4=2.51 – 3.00 5=3.01 – 3.50 6=3.51 – 4.00
F2B17A	High school math prepared for first postsecondary school	1=Not at all 2=Somewhat 3=A great deal
F2B17B	High school science prepared for first postsecondary school	1=Not at all 2=Somewhat 3=A great deal
<i>Active learning experiences</i>		
F3A14D	Community-based project	0=No 1=Yes
F3A14F	Mentoring	0=No 1=Yes
<i>Interactions with faculty and advisor</i>		
F2B18A	Talk with faculty about academic matters outside of class	1=Never 2=Sometimes 3=Often
F2B18B	Meet with advisor about academic plans	1=Never 2=Sometimes 3=Often
F3A14B	Research project with faculty member outside course/program requirements	0=No 1=Yes

(Continued)

Table 2 (Continued)

Variable Name	Variable Description	Measure
<i>Engagement with enriching educational practices</i>		
F3A14A	Internship/co-op/field experience/student teaching/clinical assignment	0=No 1=Yes
F3A14C	Study abroad	0=No 1=Yes
F3A14E	Culminating senior exp.	0=No 1=Yes
VOLUNTEER_1 (derived from F2D11)	Volunteer services participation	0=No 1=Less than once a month 2=At least once a month but not weekly 3=At least once a week
Dependent Variable:		
STEM BA Attainment (created based on these two variables)		
F3TZHIGHDEG	Transcript: Highest known degree attained as of June, 2013	1=certificate or diploma 2=Associate's degree 3=Bachelor's degree 5=Master's degree 7=Doctoral degree
F3TZSTEM2CRED	Transcript: Ever earned a postsecondary credential in a STEM field as of June 2013 (NSF grant definition)	0=no PS cred in STEM field 1=Undergraduate cred in STEM field 2=UG and graduate cred or graduate in STEM field

Data Analysis Procedures

This section provides information about statistical analysis and procedures used to answer each research question. Using SPSS Statistics 22, the study conducted descriptive statistics to answer RQ1; performed *Chi*-square tests and independent sample *t*-tests to answer RQ2; and conducted sequential logistic regression analysis to answer RQ3. Table 3 lists each research question with the statistical analysis that was performed to answer the question.

Table 2

Data Analysis

Research questions	Variables used	Analysis
RQ1: What are the demographic characteristics and precollege academic preparation of all community college transfer students in the sample?	Gender, Race/ethnicity, SES High school GPA, High school math preparation, High school science preparation	Descriptive (Frequencies)
RQ2: Among community college transfers, to what extent do STEM BA completers differ from the STEM BA non-completers regarding their demographic characteristics, precollege academic preparation, and college engagement?	Gender, Race/ethnicity, SES, High school GPA, High school math preparation, High school science preparation, Working on coursework at the library, Using the web to access school library for coursework, Community-based project, Mentoring. Talking with faculty about academic matters, Meeting with the advisor about academic plans, Research with faculty, Internship, Study abroad, Culminating senior experience, Volunteer service	Comparative (Independent samples <i>t</i> -tests, and <i>Chi</i> -square tests)
RQ3: For community college transfer students, to what extent are their demographic characteristics, precollege academic preparation, and college engagement related to their STEM BA attainment? Dependent variable: STEM BA Attainment	Gender, Race/ethnicity, SES, High school GPA, High school math preparation, High school science preparation, Working on coursework at the library, Using the web to access school library for coursework, Community-based project, Mentoring, Talking with faculty about academic matters, Meeting with advisor about academic plans, Research with faculty, Internship, Study abroad, Culminating senior experience, Volunteer service	Sequential logistic regression

Prior to the analyses of the data, a normalized weight variable was calculated based on the third follow-up survey respondent weight (F3QW). The normalized weight is defined as “the weight for each case divided by the mean weight of all the cases in the sample” (Dowd & Dugan, 2001, p.7). This weight reproduces the percentages in the population of ELS:2002 participants who entered postsecondary education via a community college and later transferred to a 4-year university, and the counts of the research sample (N=1761).

Descriptive Statistics

Transfer students’ demographic characteristics and precollege academic preparation were analyzed using frequencies and cross-tabulations to provide an overall picture of community college transfer students in the sample.

Descriptive statistics were used to answer RQ1. Particularly, the frequencies and percentages were reported to demonstrate the demographic backgrounds and precollege characteristics of the sample, STEM BA completers, and STEM BA non-completers. The demographic background included gender, race/ethnicity, and SES. The precollege academic preparation is represented by students’ GPA earned in high school and the level of high school preparation in math and science for college.

Comparative Analyses

Comparative analyses, including *Chi*-square analyses and *t*-tests were conducted to answer RQ2. The type of comparative analysis was chosen based on the type of variable to be analyzed (scale, nominal, or dichotomous).

All nominal variables (gender, race/ethnicity) and dichotomous variables (community-based project, mentoring, research with faculty, internship experience, study abroad, and culminating senior experience) were analyzed using the *Chi*-square analyses. The analyses were

conducted to determine whether there is significant association between these variables and STEM BA completion.

Independent samples *t*-tests were conducted to compare the mean scores of two groups of community college transfer students, STEM BA completers and STEM BA non-completers, with regards to their use of library services, interactions with faculty and advisors, and participation in the volunteer service. These are scale variables. The Levene's test for equal variances was performed to test whether equal variances of the two groups could be assumed. The *p* values in the Levene's test were then compared with the alpha level of .05 for all analyses. A value of *p* less than or equal to the alpha level of .05 indicated that the variances could not be assumed equal. On the other hand, if the *p* value of the Levene's test was greater than .05, the variances could be considered equal.

The significance value (2-tailed) was employed to determine the significance of the relationship. If $p \leq .05$, the researcher could reject the null hypothesis, indicating that there is a statistical significant difference between STEM BA completers and STEM BA non-completers. If $p > .05$, the researcher would fail to reject the null hypothesis, implying that there was no statistically significant difference between the two groups.

Sequential Logistic Regression

To answer RQ3 for this study, a sequential logistic regression was employed as a statistical approach since the dependent variable for this research question, STEM BA attainment, is a dichotomous variable and the predictors are categorical (Tabachnick & Fidell, 2013).

The predictors, or independent variables, were six demographic and precollege factors, and 11 variables pertaining to engagement in a wide range of activities: 1) engagement with

active learning experiences, 2) interactions with faculty and advisors, and 3) engagement with enriching educational practices. These predictors were entered by blocks into the logistic regression models. The evaluation of blocks allowed for comparisons across groups of predictors and provided insight into which type of engagement was most predictive of BA STEM attainment (Tabachnick & Fidell, 2013, Wang, 2013a).

- 1) Block 1 included demographic and precollege factors: gender, race/ethnicity, SES, high school GPA, high school math preparation, and high school science preparation.
- 2) Block 2 represented engagement with active learning experiences and included variables pertaining to working on coursework at the library, using the web to access school library for coursework, community-based project, and mentoring.
- 3) Block 3, which consisted of variables pertaining to interactions with faculty and advisors, included: talking with faculty about academic matters outside of class, meeting with the advisor about academic plans, and research with faculty.
- 4) Block 4, represented engagement in enriching educational practices, including four factors: having the internship experience, participation in the study abroad program, having the culminating senior experience, and participation in the volunteer service.

The following regression equation was used:

$$u=b_0+b_1X_1+b_2X_2+b_3X_3+\dots b_{17}X_{17}$$

with constant b_0 , coefficients b_j , and predictors X_j for 17 predictors ($j = 1, 2, 3, \dots, 17$):

X_1 refers the student's gender, X_2 represents the student's race/ethnicity, X_3 pertains to SES; X_4 is high school GPA, X_5 represents high school math preparation, X_6 captures high school science preparation (Block 1);

X_7 points to working on coursework at the library, X_8 is using the web to access school

library for coursework, X_9 represents participation in the community-based project,

X_{10} pertains to participation in the mentoring program (Block 2);

X_{11} is talking with faculty about academic matters, X_{12} represents meeting with the

advisor about academic plans, X_{13} refers to doing research with faculty (Block 3);

X_{14} captures the student's experience with internship, X_{15} represents participation in the

study abroad program, X_{16} pertains to the culminating senior experience, and

X_{17} represents participation in the volunteer service (Block 4).

The outcome variable is the probability of having one outcome or another (STEM BA attainment or not) based on a nonlinear function of the best linear combination of predictors, with two outcomes:

$$\hat{Y}_i = \frac{e^u}{1+e^u}$$

where \hat{Y}_i is the estimated probability that the i th case ($i = 1, 2, 3, \dots, 17$) is one of the categories and u is the regression equation presented above. This linear regression equation creates the *logit* or log of the odds:

$$\ln\left(\frac{\hat{Y}}{1-\hat{Y}}\right) = b_0 + \sum b_j X_{ij}$$

That is, the linear regression equation is the natural (\log_e) of the probability of being in one group (STEM BA attainment, in this case) divided by the probability of being in the other group (STEM BA non-attainment). The procedure for estimating coefficients is maximum likelihood (log-odds can range from minus infinity to plus infinity), and the goal was to find the best linear combination of predictors to maximize the probability of obtaining the observed outcome frequencies (Tabachnick & Fidell, 2013). Figure 3 shows the analytical model of the study, taking into account demographic background, precollege academic preparation, and college engagement.

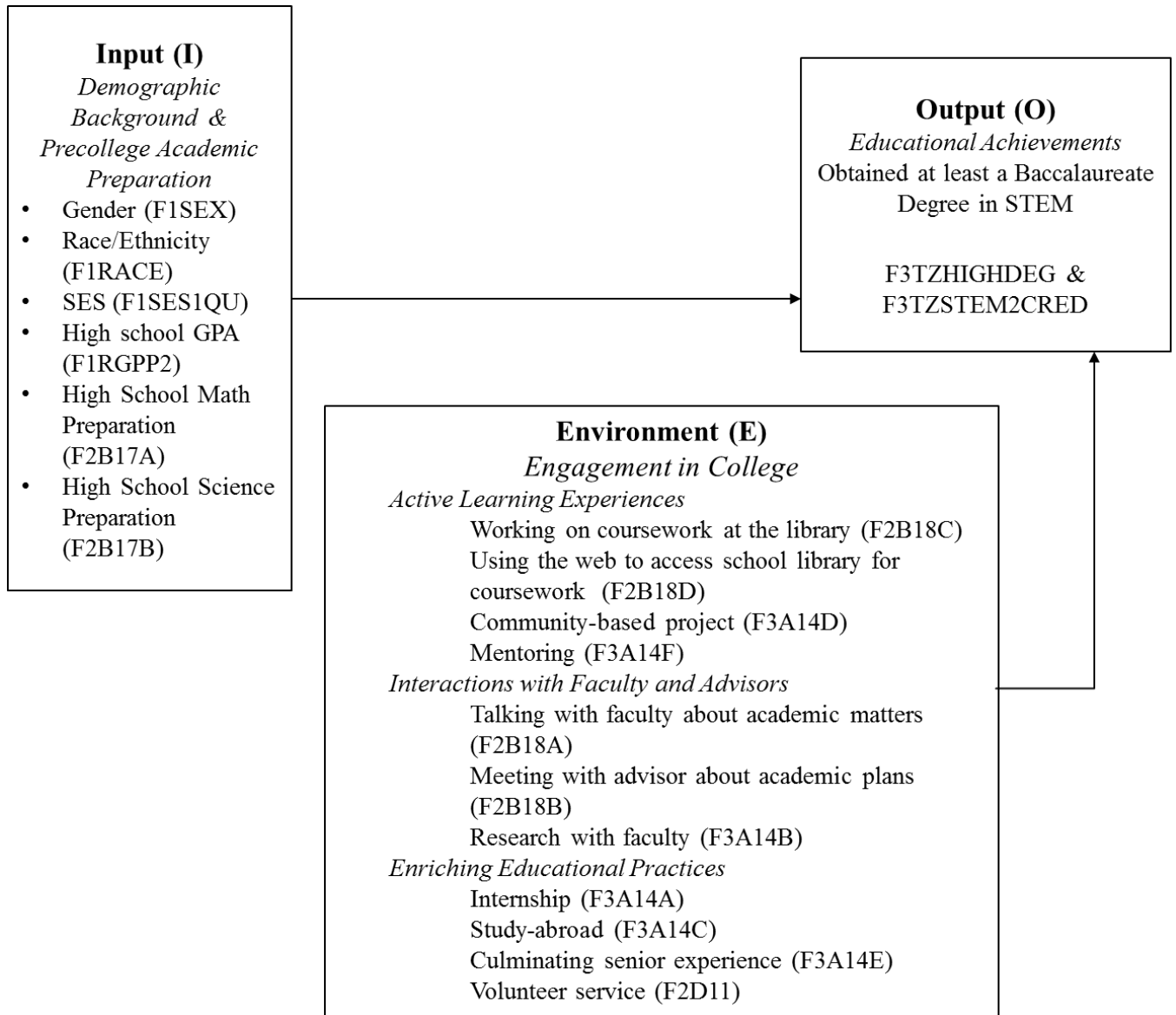


Figure 3 Analytical model of STEM baccalaureate degree attainment (sequential logistic regression)

Limitations of the Study

There are a number of limitations with the current study. Since the study employed an existing dataset, some of the limitations are associated with what the dataset offered. Given the information available in ELS:2002, the study could not seek to account for all engagement variables that might impact the baccalaureate degree attainment of community college transfer students. Even though Astin (1993b) stated that “environment refers to the various programs, policies, faculty, peers, and educational experiences to which the student is exposed” (p. 7), students’ interactions with peers and experiences with the institutional policies were not part of this study due to the lack of such information in the datasets.

Another limitation of the study is that many items of the data used for this study were self-reported. The self-reporting nature of the survey could have resulted in students’ misrepresentation of their experiences, hence, skewing the data. The findings of the study were also constrained by the decision of a student to not respond to certain survey items.

Findings regarding engagement with the community-based project, mentoring, research project with faculty member, internship experience, study abroad, and culminating senior experience, were limited to the reflection of past experiences of transfer students since the information was collected in the third follow-up when many had already graduated from college. Therefore, the findings pertaining to these aspects might not fully capture students’ real-time experiences.

Another limitation is data pertaining to some college experience (i.e. participation in the community-based project, mentoring program, internship program, study abroad, and volunteer service) was collected when some students could still be enrolled in community college and others had already transferred. Therefore, while the study was able to identify aggregated effects

of these college engagement factors in predicting STEM BA attainment among community college transfers, determining whether the context of engagement behavior—engagement in community colleges as opposed to 4-year institutions or both places—matters in affecting student degree outcomes, is beyond the scope of the current study.

Lastly, because ELS:2002 follows a particular high school cohort, it does not account for the experiences of non-traditional age students attending community colleges. Adult learners, or non-traditional age community college transfer students, have unique experiences while pursuing a STEM degree (Allen & Zhang, 2016). Thus, the exclusive examination of traditional-age college students limits the study's generalizability to the population of all community college transfers (Wang, 2013a).

Delimitations of the Study

In addition to the limitations caused by the nature of the extant datasets, the study was purposefully delimited in a number of areas. First, the study was delimited to only community college students who attempted and succeeded in transferring to a 4-year institution. As a result, the experiences of those who did not transfer or attained only an associate degree in STEM were not examined. Second, the study focused on the baccalaureate attainment in STEM, exclusively, as an outcome. Therefore, it limited the generalizability to a larger group: community college transfer students who successfully attain at least a bachelor's degree in other fields of study.

Summary

Chapter 3 provides information regarding research questions, the database used, sample, variables, and the procedure for data analysis. The chapter also addresses the limitations and delimitations of the study. In the next chapter, results of each research question will be presented.

CHAPTER FOUR: RESULTS

Overview

This dissertation study sought to explore factors that predict the baccalaureate degree attainment in STEM fields of study (STEM BA attainment) among community college transfer students. Specifically, this study aimed to examine whether community college transfers' STEM BA attainment is influenced by their demographic characteristics, precollege academic preparation, and level of engagement in college. Applying the Input-Environment-Output, or I-E-O model (Austin, 1993b) and employing data drawn from the Educational Longitudinal Study (ELS:2002), this study used the following variables as predictors of STEM BA attainment among community college transfers,

Input, including gender, race/ethnicity, socio-economic status (SES), high school grade point average (GPA), and the extent to which the students perceived their high school math and science prepared them for their postsecondary education; and

Environment, including 1) engagement with active learning experiences (i.e., the use of library service to work on coursework, and participation in community-based project and mentoring program); 2) interactions with faculty and advisor (i.e., frequency of interactions with faculty and advisor about academic matters, and participation in the research project with faculty); and 3) engagement with enriching educational practices (i.e., participation in the internship program, study abroad opportunities, culminating senior experiences, and volunteer services).

Finally, the *output* variable of this study was the STEM BA attainment, which was defined as community college transfer students' degree attainment in STEM fields of study at the baccalaureate level or above.

This chapter first provides a summary of the demographic background and precollege academic preparation of the community college transfer students in ELS:2002 data. It presents the demographic background and precollege academic preparation of the students who obtained at least a baccalaureate degree in STEM (STEM BA completers) and those who did not earn a STEM bachelor's degree (STEM BA non-completers). The second section of the chapter presents results regarding the differences (or lack thereof) between STEM BA completers and STEM BA non-completers with regard to their demographic backgrounds (i.e., gender, race/ethnicity, SES), high school preparation (i.e., high school GPA, math and science preparation), and engagement with a wide variety of domains while attending college. Next, this chapter discusses the results of the sequential logistic regression analysis. Then, it offers a summary of the extent to which students' precollege background and college engagement predict their STEM BA attainment. Finally, this chapter provides a summary of the findings and an introduction to the final chapter of the dissertation.

The following research questions guided this study:

RQ1: What are the demographic characteristics (i.e., gender, race/ethnicity, SES) and precollege academic preparation (i.e., high school GPA and high school preparation in math and science for postsecondary education) of all community college transfer students in the sample? Additionally, what are the demographic characteristics and precollege academic preparation of the STEM BA completers and the STEM BA non-completers?

RQ2: Among community college transfers, to what extent do STEM BA completers differ from the STEM BA non-completers regarding their demographic characteristics, precollege academic preparation, and college engagement?

RQ3: For community college transfer students, to what extent are their demographic

characteristics, precollege academic preparation, and college engagement related to their STEM BA attainment?

Results of Research Question 1

For the first research question, I conducted descriptive analyses to investigate the demographic backgrounds and precollege academic preparation of all community college transfer students in the sample. I also employed the descriptive statistics to provide an overall portrayal of the STEM BA completers and the non-completers.

The sample of this study included 1,761 community college transfer students. These students were selected based on the following two criteria: 1) their first known postsecondary institution was a 2-year institution, and 2) they attended a known 4-year institution sometime in their academic journey. The community college transfer students were further categorized into two groups, 1) students who obtained at least a bachelor's degree in STEM fields of study as of June 2013 (BA STEM completers), and 2) students who did not obtain any degree or obtained a degree in non-STEM fields of study (BA STEM non-completers). In the sample, 412 individuals were identified as the BA STEM completers. After appropriate weighting using the normalized weight, which was calculated based on variable F3QWT-the third follow-up questionnaire respondent weight, this sample generalized to the population of 10th graders in Spring 2002 who entered postsecondary education via a community college and later transferred to a 4-year university.

Descriptive Analysis of Community College Transfer Students

This section provides a summary of the descriptive statistics of the transfer students' backgrounds and precollege preparation. More detailed information is presented in Table 4.

Table 3

Descriptive Analysis of Demographic Characteristics and Precollege Preparation of All Community College Transfers, STEM BA Completers, and STEM BA Non-Completers

Variables	All students (N=1761)		STEM BA completers (n=412)		STEM BA non- completers (n=1349)	
	<i>N</i>	%	<i>n</i>	%	<i>n</i>	%
Gender						
Male	787	44.7	159	38.5	628	46.6
Female	974	55.3	254	61.5	720	53.4
Race/Ethnicity						
White, non-Hispanic	1073	61.0	272	65.9	802	59.5
Asian	102	5.8	38	9.2	64	4.7
Black/African American	251	14.3	37	9.0	214	15.9
Hispanic	265	15.1	53	12.8	212	15.7
American Indian	11	0.6	2	0.5	9	0.7
Multi-racial	58	3.3	11	2.7	47	3.5
SES						
Lowest quartile	357	20.3	67	16.3	290	21.5
Second quartile	441	25.0	85	20.6	356	26.4
Third quartile	505	28.7	127	30.8	378	28.0
Highest quartile	458	26.0	133	32.3	325	24.1
High school GPA						
0.00-1.00	13	0.8	2	0.5	10	0.8
1.01-1.50	26	1.6	0	0.0	26	2.1
1.51-2.00	144	9.0	17	4.6	127	10.4
2.01-2.50	312	19.4	42	11.0	271	22.2
2.51-3.00	425	26.4	92	24.1	332	27.1
3.01-3.50	409	25.5	105	27.5	304	24.9
3.51-4.00	278	17.3	124	32.5	153	12.5
High school math preparation						
Not at all	156	10.3	42	10.9	114	10.0
Somewhat	716	47.1	160	41.6	556	49.0
A great deal	648	42.6	183	47.5	465	41.0
High school science preparation						
Not at all	305	20.1	69	18.0	235	20.8
Somewhat	682	45.0	164	42.7	518	45.9
A great deal	527	34.8	151	39.3	375	33.2

Gender. Over half (55.3%) of the transfer students in the sample were female. While

female students accounted for 61.5% of the STEM BA completers, they made up a slightly

smaller proportion (53.4%) of the STEM BA non-completers.

Race/Ethnicity. The majority (61.0%) of the transfer students identified themselves as White, followed by Hispanic (15.1%) and Black/African American (14.3%). Almost 6.0% reported that they were Asian. Students who identified with more than one racial background made up 3.3% of the whole group. Finally, American Indians or Alaska Natives accounted for less than one percent (0.6%) of the sample.

Among the STEM BA completers, almost two-thirds (65.9%) were self-identified as White. Hispanics accounted for 12.8% of this sub-sample. The proportions of Black/African Americans and Asian students were almost equal, making up 9.0% and 9.2% of the STEM BA completers group, respectively. Only a small percentage of STEM BA completers were self-identified as multi-racial (2.7%) and American Indian (0.5%).

Among STEM BA non-completers, 59.5% identified as White. Hispanic (15.9%) and Black/African American (15.7%) were almost equally represented. The proportion of Asian was less than one-third of each of the two aforementioned groups—they comprised only 4.7% of the STEM BA non-completer sub-sample. Students of multi-racial background represented only 3.5% of this sub-sample, and American Indian, once again, accounted for less than one percent (0.7%) of the non-completers.

SES. The highest proportion of community college transfers (28.7%) were from medium-high SES group (in the third quartile), followed by the highest SES quartile (26%). Then, a quarter (25.0%) were in the second SES quartile. Only one in five (20.3%) community college transfer students had SES in the lowest quartile.

For the STEM BA completers, almost one in three (32.3%) of the students were from the highest SES quartile, followed by 30.8% with an SES in the third quartile. One in five (20.6%) of the STEM BA degree holders came from medium-low SES group (in the second quartile). Just

16.3% of the STEM BA completers had a SES of the lowest quartile.

For the STEM BA non-completer, the largest group (28.0%) had a SES in the third quartile, followed by 26.4% in the second SES quartile. Almost a quarter (24.1%) of the STEM BA non-completers came from families with the highest SES, and slightly more than one-fifth (21.5%) had a SES in the lowest quartile.

High school GPA. Among all community college transfers, over half of the sample had a high school GPA from 2.51 to 3.50. Specifically, 26.4% had a GPA between 2.51 and 3.00, and 25.5% earned a GPA from 3.01 to 3.50. Nearly one in five (19.4%) of the transfer students had a GPA between 2.01 and 2.50. The highest achievers, who had a GPA from 3.51 and 4.00, accounted for 17.3% of the community college transfer sample. Students with a high school GPA of 2.00 or below made up 11.4% of the sample.

For the STEM BA completers, almost one-third (32.5%) were highest academic achievers in high school, earning a GPA from 3.51 to 4.00, followed by students whose GPA ranged from 3.01 to 3.50 (27.5%). Almost a quarter (24.1%) of the STEM BA holders received a GPA from 2.51 to 3.00. More than one out of ten (11%) had a GPA between 2.01 and 2.50. Less than 5% of the STEM BA completers had a high school GPA of 2.00 or below.

For STEM BA non-completers, the majority of the students had a high school GPA from 2.51 to 3.50. Specifically, 27.1% had a GPA between 2.51 and 3.00; and almost a quarter (24.9%) received a GPA between 3.01 and 3.50. Those with high school GPA spanning from 2.01 to 2.50 accounted for 22.2% of the STEM BA non-completers. Among these STEM BA non-completers, 12.5% were high school highest achievers, earning a GPA between 3.51 and 4.00. The lowest achievers, accounting for 12.9%, reported that their GPA was 2.00 or below.

High school math preparation. This variable measured the extent to which the students

perceived their high school math prepared them for their first postsecondary institution. This variable was measured on a 3-point scale, including “not at all,” “somewhat,” and “a great deal.” For all community college transfer students in the sample, 47.1% reported that their high school math somewhat prepared them for the first postsecondary school. Those with the most positive perception, reporting that their high school math prepared them a great deal for the first postsecondary institution, accounted for 42.6% of the transfer sample. Only one in ten (10.3%) among community college transfer students responded that their high school math did not prepare them at all for their first postsecondary school.

For the STEM BA completers, 47.5% perceived that their high school offered them a great deal of preparation for their postsecondary education. Slightly over two out of five (41.6%) reported high school math somewhat prepared them for college. Only 10.9% rated that their high school math did not prepare them at all for college.

For STEM BA non-completers, almost half (49%) indicated that their high school math somewhat prepared them for postsecondary enrollment. Slightly over two out of five (41%) perceived that they received a great deal of math preparation. Only one in ten (10%) considered that their high school math did not prepare them for college.

High school science preparation. This variable measured the level of high school preparation in science for college education. Again, for this survey item, the students were asked to indicate, on a 3-point scale, “not at all”, “somewhat”, and “a great deal”, how much their high school science prepared them for their first postsecondary institution.

For all community college transfer students in the sample, 45.0% indicated that their high school science somewhat prepared them for their first postsecondary school. Slightly over one-third (34.8%) reported that their high school math prepared them a great deal for the first

postsecondary school. One-fifth (20.1%) responded that their high school math did not prepare them at all for their first postsecondary school.

For the STEM BA completers, 42.7% considered that their high school science somewhat prepared for college. More than one-third (39.3%) perceived that they received a great deal of science preparation from high school for their postsecondary education. Students who reported that their high school science did not prepare them for college accounted for less than one fifth (18.0%) of this sub-sample.

For the STEM BA non-completers, the largest group (45.9%) perceived that their high school science somewhat prepared them for college. A third (33.2%) indicated that they obtained a great deal of preparation in science from their high school. One in five (20.8%) reported that they did not receive science preparation at all from high school.

Results of Research Question 2

The second research question aims to investigate to what extent STEM BA completers differ from STEM BA non-completers regarding their demographic characteristics, precollege academic preparation, and college engagement.

Both *Chi-square* tests and independent samples *t*-tests were conducted to determine whether any significant differences existed between STEM BA completers and STEM BA non-completers with regard to their demographic background, precollege preparation, and engagement in college.

Results of *Chi-square* Tests

Chi-square tests were used for the following nominal and dichotomous variables.

- a) Gender and race/ethnicity (nominal variables representing students' demographic background);

- b) community-based project and mentoring (dichotomous variables pertaining to students' engagement with active learning experiences);
- c) research project with faculty (a dichotomous variable representing students' interactions with faculty and advisors);
- d) internship and culminating senior experience (dichotomous variables regarding students' engagement with enriching educational practices).

Results of the *Chi*-square tests are displayed in detail in Table 5.

Gender. The following null and alternative hypotheses were developed to guide the examination of the differences between STEM BA completers and STEM BA non-completers with regard to their gender distribution.

H₀: Among community college transfer students, there is no difference between STEM BA completers and STEM BA non-completers regarding their gender distribution.

H₁: Among community college transfer students, there is a difference between STEM BA completers and STEM BA non-completers regarding their gender distribution.

The *Chi*-square test indicated that the *p*-value was less than .01, and thus the null hypothesis should be rejected. That is, there is an association between gender and STEM BA attainment. More specifically, the proportion of female students in STEM BA completers was higher when compared with their non-completer counterparts, $\chi^2(1, n=1761)=8.37, p < .01$.

Table 4

Results of Chi-square Test

Variable	Percentage among		Chi-square	df	p	
	STEM BA Completers	STEM BA non-Completer				
Gender			8.37	1	.004	**
Male	38.5	46.6				
Female	61.5	53.4				
Race/ethnicity			26.11	5	.000	***
White	65.9	59.5				
Asian	9.2	4.7				
Black/African American	9.0	15.9				
Hispanic	12.8	15.7				
American- Indian	0.5	0.7				
Multi-racial	2.7	3.5				
Community-based project (Yes)	31.1	15.6	45.91	1	.000	***
Mentoring (Yes)	21.9	12.0	23.83	1	.000	***
Research (Yes)	19.0	7.5	42.92	1	.000	***
Internship (Yes)	59.1	38.7	50.95	1	.000	***
Study abroad (Yes)	8.1	5.6	3.42	1	.065	
Culminating senior exp. (Yes)	38.6	19.5	59.38	1	.000	***

Note: * $p < .05$; ** $p < .01$; *** $p < .001$

Race/Ethnicity. The following null and alternative hypotheses were developed to guide the examination of the differences between STEM BA completers and STEM BA non-completers with regard to their race/ethnicity distribution.

H₀: Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding their race/ethnicity distribution.

H₁: Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completers regarding their race/ethnicity distribution.

The *Chi*-square test found that the *p*-value was less than .001, implying that the null hypothesis should be rejected. More specifically, a statistically significant relationship did exist between STEM BA completion and race, $\chi^2 (5, n=1762)=26.11, p<.001$.

Community-based project. To guide the investigation of the differences between STEM BA completers and STEM BA non-completers in terms of their participation in the community-based project, the following null and alternative hypotheses were employed:

H₀: Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding their participation in the community-based project.

H₁: Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completers regarding their participation in the community-based project.

As shown in the *Chi*-square test's results, the *p*-value was less than .001, and thus the null hypothesis should be rejected. In other words, there is a statistically significant difference between STEM BA completers and STEM BA non-completers with regard to their participation in the community-based project, $\chi^2 (1, n= 634)=45.91, p<.001$. More specifically, a higher

percentage of STEM BA completers (31.1%) participated in community-based projects when compared to the non-completers (15.6%).

Mentoring. For the examination of the differences between STEM BA completers and STEM BA non-completers with respect to their participation in a program in which they were mentored, these guiding null and alternative hypotheses were developed:

H₀: Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding their participation in the mentoring program.

H₁: Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completers regarding their participation in the mentoring program.

The *Chi*-square test found that the *p* value is less than .001, indicating that the null hypothesis should be rejected. More specifically, there is a statistically significant relationship between STEM BA completion and participation in a mentoring program, $\chi^2(1, n=1640)=23.83$, $p<.001$. Over one in five students (21.9%) of STEM BA completers participated in a mentoring program compared with only 12.0% of non-completers who had such an experience.

Research with faculty. The following null and alternative hypotheses were employed to guide the investigation of the differences between STEM BA completers and STEM BA non-completers with regard to their participation in the research project with faculty:

H₀: Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding their participation in the research projects with faculty.

H₁: Among community college transfers, there is a difference between STEM BA

completers and STEM BA non-completers regarding their participation in the research projects with faculty.

The *Chi*-square test found that the p value is less than .001, implying that the null hypothesis should be rejected. This result demonstrated that a statistically significant relationship between STEM BA completion and participation in research with faculty existed, $\chi^2 (1, n=1642)=42.92, p <.001$. The proportion of STEM-completers who participated in the research project with faculty (19.0%) was considerably higher than the proportion of non-completers who participated in such a project (7.5%).

Internship. The investigation of the differences between STEM BA completers and STEM BA non-completers in terms of to their engagement with the internship experience was guided by the following null and alternative hypotheses:

H₀: Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding their engagement with the internship experience.

H₁: Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completers regarding their engagement with the internship experience.

As shown in Table 5, the p value is less than .001, indicating that the null hypothesis should be rejected, or a statistically significant relationship did exist between STEM BA completion and having the internship experience, $\chi^2 (1, n=1645)=50.95, p <.001$. Among STEM BA completers, more than half (59.1%) had the internship experience whereas less than 40% of the non-completers (38.7%) did while in college.

Culminating senior experience. The following null and alternative hypotheses were

adopted to guide the examination the differences between STEM BA completers and STEM BA non-completers with regard to their engagement with the culminating senior experience:

H₀: Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding their engagement with culminating senior experience.

H₁: Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completers regarding their engagement with culminating senior experience.

The *p* value for the *Chi*-square test is less than .001, indicating that the null hypothesis should be rejected. More specifically, there was a statistically significant relationship between STEM BA completion and their engagement in culminating senior experience, $\chi^2(1, n=1643)=59.38, p < .001$. Among non-completers, only less than one in five (19.5%) students participated in the culminating senior experience whereas for STEM BA completers, almost 40% (38.6%) of the students had such an experience.

Study abroad. The following null and alternative hypotheses were adopted to guide the examination of the differences between STEM BA completers and STEM BA non-completers with regard to their participation in a study abroad program:

H₀: Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding their participation in a study abroad program.

H₁: Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completers regarding their participation in a study abroad program.

The *Chi-square* test result indicated that the p value is greater than .05, so the researcher failed to reject the null hypothesis. That means, there was no difference between STEM BA completers and STEM BA non-completers in terms of the proportion of them who participated in a study abroad program, $\chi^2 (1, n=1637)=3.42, p=.07$.

Results of the Independent Samples *t*-Tests

Independent sample *t*-tests were employed to analyze the following scale variables:

- a) SES (measured on a 4-point scale);
- b) high school GPA (measured on a 7-point scale), high school math preparation (measured on a 3-point scale), and high school science preparation for college education (measured on a 3-point scale);
- c) working on coursework at library and using the web to access school library for coursework (two variables on engagement measured on a 3-point scale and representing students' engagement while at the community college);
- d) talking with faculty about academic matters outside of class and meeting with advisor about academic plans (two variables measured on 3-point scale and represent the experience specifically at the community college); and
- e) volunteer service (a variable measured on a 4-point scale).

The variances of the dependent variable within the population were evaluated by the use of Levene's test for equality of variances. A statistically significant result produced by the Levene's test ($p < .05$) indicates that the variances of the dependent variables are significantly different and that equal variances are not assumed (Morgan, Leech, Gloeckner, & Barrett, 2007; Urdan, 2010). Accordingly, eight variables (SES, high school GPA, high school science preparation, working on coursework at library, using the web to access school library for

coursework, interactions with faculty, meeting with the advisor, and volunteer participation) did not violate the assumption of equal variances. For high school math preparation, equal variances were not assumed.

The results of the independent samples *t*-tests are displayed in detail in Table 6.

SES. The following null and alternative hypotheses were developed to guide the examination of the differences between STEM BA completers and STEM BA non-completers with regard to their SES:

H_0 : Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding their SES.

H_1 : Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completers regarding their SES.

The *p* value of the *t*-test was smaller than .001, so the null hypothesis should be rejected. As such, a statistically significant difference was identified between STEM BA completers ($M=2.79$, $SD=1.07$) and STEM BA non-completers ($M=2.55$, $SD=1.08$) with regard to their SES, $t(1759)=-4.09$, $p < .001$. This indicates that on average, STEM BA completers came from family with higher SES than did STEM BA non-completers.

High school GPA. The exploration of the differences between STEM BA completers and STEM BA non-completers with regard to their high school GPA was guided by the following null and alternative hypotheses:

H_0 : Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding their high school GPA.

H_1 : Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completers regarding their high school GPA.

Table 5

Results of Independent Sample t-Test

Variable	STEM BA Completer			STEM BA Non-Completer			<i>t</i>		95% Confidence Interval of the Difference	
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>			Lower	Upper
SES	412	2.79	1.07	1349	2.55	1.08	-4.092	***	-.37	-.13
H.S. GPA	383	4.70	1.21	1223	3.97	1.31	-9.643	***	-.87	-.58
H.S. math preparation	385	2.37	.67	1134	2.31	.64	-1.466		-.13	.02
H.S. science preparation	384	2.21	.73	1129	2.12	.73	-2.089	*	-.17	-.01
Coursework at library	383	2.20	.70	1132	2.07	.75	-3.005	**	-.22	-.05
Use web to access library	383	2.26	.76	1135	2.18	.76	-1.778		-.17	.01
Talk with faculty	384	2.03	.69	1136	1.96	.67	-1.640		-.14	.01
Meet with advisor	384	2.04	.62	1136	2.01	.67	-.731		-.11	.05
Volunteer service	389	.97	1.09	1236	.76	1.04	-3.388	*	-.33	-.09

Note: Variations in *n* are due to missing data.

* $p < .05$; ** $p < .01$; *** $p < .001$

Because the p value of the t -test was smaller than .05, the null hypothesis should be rejected. This suggests a difference between STEM BA completers and STEM BA non-completers in terms of their high school GPA, $t(1604) = -9.64, p < .001$. This indicates that on average, STEM BA completers ($M = 4.70, SD = 1.21$) achieved a higher high school GPA than did STEM BA non-completers ($M = 3.97, SD = 1.31$).

High school math preparation. The following null and alternative hypotheses were adopted to guide the examination of the differences between STEM BA completers and STEM BA non-completers with regard to their perception of the degree to which their high school math prepared them for higher education:

H_0 : Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding their high school math preparation.

H_1 : Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completers regarding their high school math preparation.

Since result of the t -test found that the p value was bigger than .001, the researcher failed to reject the null hypothesis. That is, there was no difference between STEM BA completers and STEM BA non-completers regarding their perceived level of high school math preparation for college, $t(640.36) = -1.47, p = .14$.

High school science preparation. The following null and alternative hypotheses were utilized to guide the investigation of the differences between STEM BA completers and STEM BA non-completers with regard to their perception of how much preparation in science they received from their high school for their postsecondary education:

H_0 : Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding their high school science

preparation.

H₁: Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completers regarding their high school science preparation.

The p value of the t -test was smaller than .05, so the null hypothesis should be rejected.

In other words, there was a significant difference between STEM BA completers and STEM BA non-completers regarding their high school science preparation for college, $t(1511)=-2.09$, $p < .05$. More specifically, STEM BA completers perceived that they were better prepared in science for college ($M=2.21$, $SD=.73$) than did their non-completer counterparts ($M=2.12$, $SD=.73$).

Working on coursework at the library. To guide the examination of the differences between STEM BA completers and STEM BA non-completers with regard to the frequency of their utilization of the library for coursework while still attending the community college, the following null and alternative hypotheses were adopted:

H₀: Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding the frequency with which they work on coursework at library.

H₁: Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completer regarding the frequency with which they work on coursework at library.

The null hypothesis for this t -test should be rejected because the p value was found to be smaller than .01. In other words, STEM BA completers and STEM BA non-completers differed from each other regarding how frequently they did homework at the library while still attending

the community college, $t(1512)=-3.01, p<.01$. The average frequency of library use for coursework for STEM BA completers ($M=2.20, SD=.70$) was higher than that for STEM BA non-completers ($M=2.07, SD=.75$). This indicates that, while still enrolling in the community college, on average, STEM BA completers worked on coursework at the library more frequently than did STEM BA non-completers

Using of the web to access school library for coursework. The following null and alternative hypotheses were developed to guide the exploration of the differences between STEM BA completers and STEM BA non-completers with regard to the frequency with which they used the web to access school library for coursework while they were attending the community college:

H_0 : Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding the frequency with which they used the web to access school library for coursework.

H_1 : Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completers regarding the frequency with which they used the web to access school library for coursework.

The p value of the t -test was bigger than .05, so the researcher failed to reject the hypothesis, or there was no statistically significant difference between STEM BA completers and STEM BA non-completers regarding how frequently they used the web to access school library for coursework while still enrolling at the community college, $t(1516)=-1.78, p=.076$.

Talking with faculty about academic matters outside of class. For the examination of the differences between STEM BA completers and STEM BA non-completers with regard to the frequency of their interactions with faculty about academic matters outside of class at the

community college, these guiding null and alternative hypotheses were adopted:

H₀: Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding the frequency of interactions they have with faculty about academic matters outside of class.

H₁: Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completers regarding the frequency of interactions they have with faculty about academic matters outside of class.

Again, the researcher failed to reject the hypothesis as the *t*-test result indicated that the *p* value was bigger than .05. That is, no statistically significant difference was found between STEM BA completers and STEM BA non-completers regarding the frequency of their interactions with faculty about academic matters outside of class at the community college, $t(1518) = -1.64, p = .10$.

Meeting with the advisor about academic plans. For the exploration of the differences between STEM BA completers and STEM BA non-completers with regard to the frequency of their meeting with the advisor about academic plans while attending the community college, the following guiding null and alternative hypotheses were employed:

H₀: Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding the frequency of their meeting with the advisor about academic plan.

H₁: Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completer regarding the frequency of their meeting with the advisor about academic plan.

Once again, the *p* value of the *t*-test was bigger than .05, indicating that the researcher

failed to reject the null hypothesis, or no difference was detected between STEM BA completers and STEM BA non-completers regarding the frequency of their meeting with the advisor about academic plans while attending the community college, $t(1518) = -.73, p = .47$.

Volunteer service. The examination of differences between STEM BA completers and STEM BA non-completers with regard to the frequency of their participation in the volunteer service was guided by the following null and alternative hypotheses:

H₀: Among community college transfers, there is no difference between STEM BA completers and STEM BA non-completers regarding the frequency of their participation in the volunteer service.

H₁: Among community college transfers, there is a difference between STEM BA completers and STEM BA non-completer regarding the frequency of their participation in the volunteer service.

For this particular variable, the p value of the t -test was smaller than .05, so the null hypothesis should be rejected. There was, indeed, a statistically significant difference between STEM BA completers and STEM BA non-completers regarding the volunteer service participation, $t(1623) = -3.39, p < .05$. The average frequency of participation in volunteer work for STEM BA completers ($M = .97, SD = 1.09$) was higher than the average frequency of participation in volunteer work for STEM BA non-completers ($M = .76, SD = 1.04$).

Results of Research Question 3

The third research question focused on the community college transfers and aims to investigate to what extent their demographic characteristics, precollege academic preparation, and college engagement related to the probability of their attainment of at least a baccalaureate degree in STEM fields of study.

To answer this research question, a sequential logistic regression analysis was used to investigate the extent to which the independent variables predicted the dependent variable, which is STEM BA completion. Sequential logistic regression was adopted for the analysis because the dependent variable is dichotomous. According to Tabachnick and Fidell, (2013), “[l]ogistic regression allows one to predict a discrete outcome such as group membership from a set of variables that may be continuous, discrete, dichotomous, or a mix” (p. 439).

Because of the small representation of American Indian and multi-racial, these two groups were combined into one for the purpose of the logistic regression analysis. In addition, prior to performing logistic regression analysis, the collinearity diagnostics was conducted to assess the multicollinearity among the independent variables. As suggested by Tabachnick and Fidell, (2013), criteria for multicollinearity “are a conditioning index greater than 30 for a given dimension coupled with variance proportions greater than .50 for at least two different variables” (p. 91). The result of the test indicated that no multicollinearity issue was detected among variables examined.

The independent variables entered in the logistic regression model included, 1) transfer students’ background (i.e., gender, race/ethnicity, and SES) and precollege preparation (i.e., high school GPA, and high school math and science preparation); 2) engagement with active learning experiences (i.e., working on coursework at the library, using the web to access school library for coursework, and community-based project and mentoring program participation); 3) interactions with faculty and advisors (i.e., conversing with faculty about academic matters outside of class, meeting with the advisor about academic plans, and research with faculty); and 4) engagement with enriching educational practices (i.e., internship, culminating senior experience, study abroad, and volunteer service).

Tabachnick and Fidell, (2013) maintained that when using sequential logistic regression, “the researcher [can specify] the order of entry of predictors into the model” (p. 456). The independent variables discussed above were entered into the logistic regression by blocks. According to Wang (2013a), “this entry approach allowed the researcher to analyze how the effects of variables earlier in the temporal order [...] were mediated by other variables, thus gaining a deeper understanding of how the independent variables exerted the impact on [the dependent variable]” (p. 861).

Block 1 consisted of six variables pertaining to students’ background characteristics (i.e. gender, race/ethnicity, SES) and precollege academic preparation (i.e. high school GPA and the level of preparation in high school math and science). Block 2 contained four variables representing students’ engagement with active learning experiences (i.e. working on coursework at library, using the web to access school library for coursework, participation in the community-based project, and in a mentoring program). Block 3 included three variables regarding students’ interactions with faculty and advisors (i.e. talking with faculty outside of class about coursework, meeting with the advisor about academic plans, and research with faculty). Block 4 was comprised of four variables capturing students’ engagement with enriching education practices (i.e., internship, study abroad, culminating senior experience, and volunteer service).

Using IBM SPSS 20.0 software, each block was entered into the logistic regression models in a sequence. Specifically, Model 1 consisted of Block 1, Model 2 contained blocks 1 and 2, Model 3 included blocks 1, 2, and 3, and finally, all four blocks were entered in Model 4.

Results of Sequential Logistic Regression Analysis

The results of the logistic regression for all predictor variables in the model can be found in Table 7.

Table 6

Results of Logistic Regression Analysis on STEM Baccalaureate Degree Attainment in Each Model (n=1122)

Variable	Model 1		Model 2		Model 3		Model 4	
	B	β	B	β	B	β	B	β
Block 1: Background and Precollege Preparation								
Gender (<i>Ref = Male</i>)	.240	1.272	.212	1.236	.225	1.253	.206	1.229
Race/Ethnicity (<i>Ref= White</i>)								
Asian	.673 ***	1.960	.702 ***	2.017	.685 ***	1.984	.731 ***	2.078
Black/African American	.026	1.027	-.031	.970	-.061	.941	-.028	.972
Hispanic	-.007	.993	-.047	.954	-.086	.917	-.056	.945
Multi-racial	.171	1.186	.088	1.092	.074	1.077	.104	1.109
SES	.124	1.132	.105	1.111	.104	1.110	.095	1.100
High school GPA	.434 ***	1.544	.472 ***	1.533	.425 ***	1.529	.397 ***	1.487
High school math	-.026	.975	-.072	.930	-.084	.919	-.096	.909
High school science	.162	1.175	.169	1.184	.158	1.171	.164	1.179
Block 2: Active Learning Experiences								
Coursework at library			.235 *	1.265	.236 *	1.266	.224 *	1.252
Use web to access library for coursework			-.021	.980	-.018	.982	-.024	.976
Community-based			.588 ***	1.800	.478 **	1.612	.353 *	1.423
Mentoring			.410 *	1.506	.340	1.405	.227	1.254

(Continued)

Table 7 (Continued)

Variable	Model 1		Model 2		Model 3		Model 4	
	B	β	B	β	B	β	B	β
Block 3: Interactions with Faculty and Advisors								
Talking with faculty					.016	1.016	.003	1.003
Meeting with advisors					.016	1.016	.013	1.013
Research with faculty					.630 **	1.877	.500 *	1.648
Block 4: Enriching Educational Experience								
Internship							.286	1.331
Study abroad							-.082	.921
Culminating senior experience							.323 *	1.381
Volunteer service							.024	1.025
R^2	.109		.144		.154		.163	
ΔR^2	.109		.035		.01		.009	

Note: Multi-racial includes American Indian, students who were identified with more than one race, and others. β is the odd ratios.

* $p < .05$; ** $p < .01$; *** $p < .001$.

Demographic and precollege backgrounds. In all four models, being Asian and high school GPA were statistically significant predictors of STEM BA completion among community college transfers.

Race. Model 1 revealed that compared to White transfer students, Asian transfer students were 1.96 times ($p < .001$) more likely to obtain a baccalaureate degree in STEM. Model 2 revealed that, when Block 2 was added, being Asian still remained a significant predictor of STEM BA completion ($\beta = 2.017, p < .001$). When Block 3 was entered into the model, Model 3 showed that being Asian was still associated with STEM BA completion ($\beta = 1.984, p < .001$). Finally, the full model, which included all four Blocks, revealed that the odds of graduating with at least a bachelor's degree in STEM increased 107.8% for Asians ($p < .001$).

High school GPA. In Model 1, high school GPA was a positive predictor of STEM BA completion ($\beta = 1.544, p < .001$). In Model 2 and Model 3, high school GPA presented a statistically significant predictor of STEM BA attainment, $\beta = 1.533$ and $\beta = 1.529$ ($p < .001$), respectively. Finally, the full model revealed that for every one-point increase in high school GPA, the odds that the transfer student obtained a STEM baccalaureate degree increased by 48.7% ($p < .001$).

Active Learning Experiences. Among variables associated with engagement with active learning, working on coursework at the library and participation in the community-based project were found to be significant predictors of STEM BA attainment among community college transfers in all three models where they appeared. Participation in the mentoring program was only a significant predictor in the second model, which included the Block 1, background and precollege experiences, and Block 2, active learning experiences.

Working on coursework at the library. In Model 2, where both Block 1, background and

precollege preparation, and Block 2, engagement with active learning experiences, were included, working on coursework at library was found to be positively associated with STEM BA completion ($\beta = 1.265, p < .05$). When Block 3, interactions with faculty and the advisor, was added, Model 3 revealed that working on coursework at library at the community college was a predictor of STEM BA accomplishment ($\beta = 1.266, p < .05$). Finally, results in Model 4 showed that for every one-point increase in working on coursework at the library at the community college, the odds that the transfer student obtained a STEM baccalaureate degree increased by 25.2%.

Community-based project. Model 2, which included Block 1 and Block 2, illustrated that the odds of completing a STEM BA degree among community college transfer students increased by 80.0% ($p < .001$) for those who participated in the community-based project. While significant, the odds decreased to 61.2% ($p < .01$) with respect to participation in the community-based project, when Block 3 was added into the model. Lastly, the final model, with the presence of all four blocks, indicated that the odds of obtaining at least a baccalaureate degree in STEM increased 42.3% ($p < .05$) for students who participated in the community-based project.

Mentoring. Model 2 revealed that participation in the mentoring program, where the community college transfer students were mentored, was a significant predictor of STEM BA completion ($\beta = 1.506, p < .05$). However, after entering the Block 3, mentoring ceased to be a significant predictor ($\beta = 1.405, p = .076$) in Model 3. Furthermore, mentoring was no longer found to be predictive of STEM BA attainment in the last model ($\beta = 1.254, p = .249$).

Interactions with faculty and advisors. Among variables associated with student-faculty interactions, research with faculty member outside course/program requirement was found to be a statistically significant predictor of STEM BA completion among community

college transfers in both models where the variable was included.

Research with faculty. In Model 3, which included Block 1, Block 2, and Block 3, having research experience with faculty was found to be positively related with STEM BA attainment ($\beta = 1.877, p < .01$). In the last model, when Block 4 was entered, participation in research project with faculty was still found to be a significant predictor of STEM BA attainment among community college transfers ($\beta = 1.648, p < .05$). In other words, the odds of obtaining at least a baccalaureate degree in STEM increased 64.8% for students who participated in the research project with a faculty member.

Enriching educational experience. The final model, which included all of the four blocks, revealed that among variables associated with enriching educational experience, having the culminating senior experience was a statistically significant predictor of STEM BA attainment among community college transfers.

Culminating senior experience. The finding demonstrated that transfer students who had culminating senior experience were 1.38 times ($p < .05$) more likely to obtain a baccalaureate degree than were those who did not have culminating senior experience. In other words, the odds of obtaining at least a baccalaureate degree in STEM increased 38.1% for students who had the culminating senior experience.

Overall, being Asian, high school GPA, working on coursework at the library, participation in the community-based project, participation in research project with faculty member, and having the culminating senior experience were statistically significant predictors of STEM BA completion. In addition, participation in the mentoring program was shown to be positively related to the STEM BA degree attainment in the second model, which consisted of background characteristics and engagement with active learning experiences.

Model. There was an increase in the adjusted R^2 in each subsequent model. Specifically, the increase in the adjusted R^2 between the first two models was 3.5%; the increase in the adjusted R^2 between Model 2 and Model 3 was 1%; and the increase in the adjusted R^2 between the last two models was 0.9%. Each sequential increase in adjusted R^2 indicated that the prediction model improved at each step. The adjusted R^2 increased the most when the second block of variables was introduced into the model.

To determine the goodness of fit of the logistic regression model, Hosmer-Lemeshow Goodness-of-Fit test was used. This test divides observations into deciles based on a Chi-square static from observed and expected frequencies (Hosmer & Lemeshow, 2000). If the researcher fails to reject the null hypothesis (or the p value for the Chi-square test is greater than .05), it means that there is no difference between the estimates of the observed and predicted values of the dependent variables. In that case the logistic regression model has an appropriate goodness of fit to the data.

For Model 1, the test results was $\chi^2(8)=5.81$, $p=.669$. The Chi-square test found that the p value was greater than .05, which suggests that no difference was found between the estimates of the observed and predicted values of the dependent variables. Therefore, the model had a reasonable goodness of fit ($-2 \text{ Log Likelihood}=1336.14$). For Model 2, $\chi^2(8)=6.04$, $p=.643$, again, the p value was greater than .05, so the goodness of fit of the model was acceptable ($-2 \text{ Log Likelihood} = 1303.96$). For Model 3, $\chi^2(8)=4.80$, $p=.778$, once again, p value was greater than .05, indicating that the model fits well with the data ($-2 \text{ Log Likelihood}=1294.56$). Finally, for the overall model, $\chi^2(8)=3.61$, $p=.890$, the p value was also greater than .05, implying that the model had an appropriate goodness of fit ($-2 \text{ Log Likelihood}=1285.98$).

Summary

This chapter includes descriptive, comparative, and prediction analyses of community college transfer students in the ELS:2002 dataset. The types of analyses include frequency, *Chi*-square, independent samples *t*-test, and sequential logistic regression analysis. All data analyses were conducted using IBM SPSS 20.0 software.

The findings of the data analysis were presented in three sections corresponding with the three research questions that guided this study. The first section presented the results of the demographic descriptive statistics for each of three groups of students: 1) all community college transfer students, 2) STEM BA completers, and 3) STM BA non-completers.

The second section of this chapter reported the findings of the comparative analyses. The comparative analyses were conducted based on the dependent variable, the STEM BA completion. The results of the comparative analyses indicated that statistically significant differences existed between STEM BA completers and STEM BA non-completers on the following variables: 1) gender, race/ethnicity, and SES (variables pertaining to students' demographic backgrounds); 2) high school GPA and high school science preparation for postsecondary education (variables regarding precollege academic preparation); 3) work on coursework at the library, participation in the community-based project, and participation in the mentoring program (variables representing students' engagement with active learning experiences); 4) participation in research project with faculty (a variable capturing interactions with faculty and advisors); and 5) having internship experience, having culminating senior experience, and participation in volunteer services (variables pertaining students' engagement with enriching educational experiences).

The third section reported the results of the sequential logistic regression analysis for the

dependent variables STEM BA completion. Demographic characteristics, precollege academic preparation, and engagement variables were entered into the binary logistic regression analysis in four blocks. Results of the logistic regression analysis revealed that the following variables were found to be significant predictors of STEM BA completion for community college transfer students in the final model: being Asian, high school GPA, working on coursework at the library, participation in the community-based project, doing research with faculty, and having culminating senior experience. In addition, mentoring was a predictor of STEM BA attainment in Model 2. Results of the evaluation of the sequential logistic regression model showed that the prediction model improved at each step and each of the models had an appropriate goodness of fit to the data.

The results of the analyses conducted in Chapter 4 are further discussed in relationship to previous literature in Chapter 5. In addition, recommendations for policy, practice, and future research and conclusions of the study are presented in Chapter 5.

CHAPTER FIVE: DISCUSSION AND RECOMMENDATIONS

Chapter Overview

This chapter, which discusses the overall findings of the dissertation study, contains five sections. First, the chapter begins with a summary of the study. Second, the results of the study are discussed in detailed in relationship to past literature pertaining to the experience of STEM students. Third, implications for policy and practice are offered. Fourth, recommendations for future research are presented. Finally, the chapter ends with a conclusion of the study.

Summary of the Study

Chapter 1 provides an overview of the state of U.S. STEM education and workforce and a national urgency for the increase of STEM workforce with at least a baccalaureate degree. The chapter also highlights the important contribution of community colleges in providing an alternative pathway to baccalaureate degree attainment in STEM fields of study. In addition, the critical role of student engagement in college success, including degree completion, is discussed to establish the context for the current study.

Chapter 2 presents a review of literature relevant to the study. First, it provides empirical evidence of the contribution of college engagement to student success. Second, it introduces the literature focusing on community college transfer students in terms of their background characteristics, engagement, and baccalaureate degree attainment. Third, it discusses research studies on persistence and degree attainment in STEM fields of study at the undergraduate level. Fourth, the chapter provides a synthesis of literature regarding community college transfer students in STEM. Finally, the theoretical framework, or the Input-Environment-Output (I-E-O), (Astin, 1993b) model adopted by the study, is introduced.

Chapter 3 presents the methodological and analytical design of the study. It provides an

overview of the Educational Longitudinal Study (ELS:2002) data, the background and variables representing students' precollege backgrounds and college engagement, and data analysis approach. The chapter also addresses limitations and delimitations of the study.

Chapter 4 presents the results of the analyses laid out in the previous chapter. First, chapter 4 reports the comprehensive demographic background and precollege academic preparation of 1) all of the community college transfer students in the sample, 2) the transfer students who obtained at least a bachelors' degree in STEM (STEM BA completers), and 3) the transfer students who did not earn a STEM degree (STEM BA non-completers). Next, results of comparative analyses between STEM BA completers and STEM BA non-completers are provided. Finally, the results of the sequential logistic regression analysis are presented.

Chapter 5 summarizes the study and offers a further discussion of the results in consideration of previous literature. The chapter also offers recommendations for policy, practice, and future research. Finally, the conclusion of the chapter ends the dissertation.

Discussion of the Results

The discussion of the study's results is organized thematically in alignment with the theoretical framework adopted by the study, or the I-E-O model. First, the chapter discusses the results of the analyses of the *Input*, which includes students' demographic background (i.e., gender, race/ethnicity, and SES) and precollege characteristics (i.e., high school GPA, math and science preparation). Second, the chapter presents the results of the analyses of the college engagement variables, which are highlighted in the *Environment* section in the model. These college engagement variables are classified into three major groups and each consists of a number of variables. That is, 1) students' engagement with active learning experiences (i.e., working on coursework at the library, using the web to access school library for coursework,

community-based project, and mentoring), 2) interactions with faculty and advisors (i.e., interactions with faculty and the advisor, and research with faculty outside of program requirement), and 3) students' engagement with enriching educational practices (i.e., internship, study abroad, culminating senior experience, and volunteer service).

Input

In the I-E-O model (Astin, 1993b), the *input* (I) refers to background characteristics and personal qualities that the students bring along to college. Astin (1993b) and Pascarella and Terenzini (2005) noted that students' demographic backgrounds and precollege experiences contribute significantly to their educational outcomes in postsecondary enrollment. In this study, the input variables refer to the community college transfer students' demographic characteristics (i.e., gender, race/ethnicity, and SES) and precollege academic preparation (i.e., high school GPA, and math and science preparation for college)

Demographic background. Although past scholarships have consistently demonstrated that female students were less likely to persist in STEM fields of study (Ferrare & Lee, 2014) and obtain a bachelor's degree in STEM (Crisp, Nora, & Taggart, 2009; Gayles & Ampaw, 2014) than their male counterparts, this study did not find gender as a predictor of bachelor's degree attainment in STEM among community college transfer students. Previous studies found that female community college students were less likely to possess an aspiration to earn a bachelor's degree in STEM through transfer (Myers, Starobin, Chen, Baul, & Kollasch, 2015) and experienced more difficulty in academic adjustment once they transferred to a 4-year STEM program (Jackson & Laanan, 2015), but the current study found that the proportion of female students who obtained a STEM BA degree were higher than that of their male counterparts. Finding from a prior study conducted by Ma (2011) may offer an explanation to this interesting

dissonance between the previous findings and results of this current study. Although women were less likely than men to demonstrate an aspiration in pursuing STEM at the beginning of their college career, their interest in the discipline increased over time compared to men; once women declared a STEM major, they were more likely to persist than men (Ma, 2011). In addition, a plausible explanation to a higher proportion of women completing a STEM degree is that more females than males choose to obtain a STEM education via a vertical transfer route. Prior research has indicated that community colleges provided effective avenues for increasing participation women in STEM education (Berger & Malaney, 2003; Jackson & Laanan, 2011; Jackson, Starobin, & Laanan, 2013).

Regarding race/ethnicity, results of the logistic regression analysis revealed that compared to White students, Asian transfer students were more likely to earn a bachelor's degree in STEM. Consistent with this finding, a previous study focusing on students attending a Hispanic Serving Institution also found that being Asian increased the probability of students completing a STEM degree, compared to being White (Crisp et al. 2009). Among studies on community college beginners, Myers et al. (2015) indicated that Asian students were more likely to exhibit intention to pursue a baccalaureate degree in STEM through vertical transfers than were their White counterparts. On the other hand, although there has been ample evidence that Black/African American and Hispanic students were less likely to persist in their STEM studies when compared to White students (Ferrare & Lee, 2014; Garcia & Hurtado, 2011; Koledoye, Joyner, & Slate, 2011), this study did not find a relationship between being Black/African American or Hispanic and STEM bachelor's attainment among community college transfers.

In terms of SES, this current study did not identify a predictive relationship between SES and baccalaureate degree attainment in STEM among community college transfer students.

However, results of the comparative analysis revealed that for community college transfer students, those who received at least a bachelor's degree in STEM came from families of higher SES backgrounds than did STEM non-completers. This finding confirmed previous studies that students who persisted and eventually graduated with a bachelor's degree in STEM came from families of high SES (Ferrare & Lee, 2014; Gayles & Ampaw, 2014).

Precollege academic preparation. The study found that high school GPA was a positive predictor of baccalaureate degree attainment in STEM among community college transfer students. Specifically, students who achieved higher GPA in high school were more likely to complete a STEM baccalaureate degree than were those with lower GPA. This finding was congruent with previous studies that revealed a positive relationship between students' high school academic performance and their persistence in STEM (Baker & Finn, 2008; Gayles & Ampaw, 2014; Johnson, 2008). A possible explanation was that students with better high school academic performance were more academically prepared for entrance into STEM disciplines in college.

Numerous extant literature has documented a positive impact of high school math and science preparation on STEM baccalaureate degree attainment among students at 4-year institutions (Baker & Finn, 2008; Ceglie & Settlage, 2016; Lubinski & Benbow, 2006; Ma, 2011; Tai, Liu, Maltese, & Fan, 2006; Tyson, Lee, Borman, & Hanson, 2007). For community college transfer students, nevertheless, this study did not find a connection between precollege preparation in math and science and the attainment of a bachelor's degree in STEM. The discrepancy in the findings between this study and prior studies partly reflects what Wang (2013a) noted in a comparative study. While examining the academic experience and STEM choice of students who enrolled in higher education via a community college and students who

began at a 4-year institution, Wang (2013a) found that perceived math and science college readiness exerted a stronger impact on STEM choice for students at 4-year institutions than it did on community college beginners.

Environment

The *environment* (E) in the I-E-O model represents students' various experiences while attending college (Astin, 1993b). In this study, the *environment* captures students' engagement with active learning experiences, interactions with faculty and advisors, and participation in enriching educational practices. Findings of the study supported previous literature which pointed to the positive relationship between college engagement and academic outcome (Arbona & Nora, 2007; Astin 1993b; Dowd, 2004; Flynn, 2014; Hu, 2010; Wolf-Wendel et al., 2009; Ryan, 2004; Syanum & Bigatti, 2009; Wang 2009).

Active learning experiences. Engagement in active learning activities represents students' efforts to actively construct their cognitive engagement through studying in various settings as well as collaboration with other students (Hedrick, Dizen, Collins, Evans, & Grayson, 2010; Trowler, 2010). In this study, active learning encompassed the students' use of library resources for coursework while still attending the community college (including two variables, working on coursework at the library and using the web to access school library for coursework) and participation in the community-based project and mentoring. Results of the logistic regression analysis found that for community college transfer students, working on coursework at the library and participation in the community-based project were positive predictors of their baccalaureate degree attainment in STEM.

Although Kuh and Gonyea (2003) revealed that STEM students did not use the library as much as their peers pursuing other fields of studies, this study found that working on coursework

at the library, indeed, increased the odds that the transfer students received a baccalaureate degree in STEM. This may indicate that students who study in the library frequently are the ones with more dedication to their study and possess a stronger interest in STEM. Similarly, Ferrare and Lee's (2014) indicated that a strong commitment to coursework positively influenced persistence in STEM disciplines. On the other hand, the current study did not find an association between the students' use of the web to access their school library for coursework and their STEM degree completion. Furthermore, STEM BA completers and their non-completer counterparts did not differ in this regard. A plausible explanation is that the STEM BA non-completers in this study also included those who successfully obtained a bachelor's degree in disciplines outside of STEM fields. In achieving such an accomplishment, these students might have used the web to access school library for coursework as often as their peers who pursued a STEM degree.

This current study extended knowledge on the contribution of the participation in community-based projects to STEM students' success, as set forth by prior studies (Barnhardt, Sheets & Pasquesi, 2015; Quitadamo, 2018). While previous research has demonstrated that participation in a community-based project affects the acquisition of civic skills, one of the liberal arts outcomes (Barnhardt et al., 2015), this study found that such engagement also contributes to academic outcome, specifically, a baccalaureate attainment in STEM. A possible explanation to the positive relationship between community-based project involvement and STEM degree attainment among community college transfers was that community-based learning improved students' academic performance in STEM courses (Dochy, Segers, Van den Bossche, & Gijbels, 2003; Springer, Stanne, & Donovan, 1999), which is an important contributor to STEM degree completion among community college transfer students (Wang,

2015a). In addition, as noted by Keen and Baldwin (2004), community-based project represented “service done by students to meet community needs” (p. 384). Therefore, the positive association between participation in community-based projects and STEM degree attainment might be because of the differences of students’ perceptions on value of the projects. Those who participated in the projects may value contributing to the community, and, as indicated by Ceglie and Settlege (2016), the notion of “give back to the community” motivates them to persist in their STEM education. In addition, Allen and Zhang (2016) also pointed out that for a group of community college adult learners, the reason behind their successful transfer and persistence in STEM education was the linkage they perceived between a STEM career and the ability to contribute to improve the community.

The current study did not find participating in a mentoring program as a predictor of their STEM baccalaureate attainment. Nevertheless, the result of a comparative analysis did reveal that compared to STEM BA non-completers, STEM BA completers are more likely to participate in a mentoring program. A substantial amount of evidence has been offered regarding the role of mentoring program in facilitating the academic experience of community college transfer students (Cornell & Mosley, 2006; Fauria & Fuller, 2015; Lenaburg, Aguirre, Goodchild, & Kuhn, 2012; Morgan & Gerber, 2016; Wilson, 2014). This experience also included the STEM engagement and the aspiration to earn a bachelor’s degree in STEM fields for community college students (Lenaburg et al., 2012; Morgan & Gerber, 2016).

Interactions with faculty and advisors. This engagement category represents the amount of learning that occurs as a result of interacting with faculty members both inside and outside the classroom (Hedrick et al., 2010). For the purpose of this study, interactions with faculty and advisors included three variables, talking with faculty about academic matters

outside of class, meeting with the advisor about academic plans (in the community college), and participating in the research project with faculty member outside course/program requirements. The study found that only research with faculty is positively associated with community college transfer students' attainment of STEM baccalaureate degree.

Numerous studies indicated that faculty and advisors play an important role in cultivating STEM interest and promoting learning experience among community college transfer-bound students (Denner, Werner, O'Connor, & Glassman, 2014; Jackson & Laanan, 2015; Lopez & Jones, 2016; Kruse, Starobin, Chen, Baul, & Laanan, 2015; Marra, Tsai, Bogue, & Pytel, 2015; Packard & Jeffers, 2013; Packard, Tuladhar, & Lee, 2013; Zhang & Ozuna, 2015). However, interactions with faculty and advisors were not found to be predictors of students' STEM baccalaureate degree attainment in the current study. In addition, the comparative statistical tests revealed that STEM completers and non-STEM completers did not differ with regard to their interactions with faculty and advisors. A plausible explanation is that frequent consultation with faculty and advisors about academic matters is important for student success and degree attainment regardless of their major of studies (D'Amico, Dika, Elling, Algozzine, & Ginn, 2014; Flaga, 2006; Flynn, 2013). Since non-STEM completers in this current study also included those who graduated with a 4-year degree in the fields outside of STEM, they may experience some similarity in college engagement when compared to their STEM degree achieving counterparts. Interactions with faculty and advisors may be one of those areas where successful STEM students do not differ from students graduating with other degrees.

Nevertheless, the current study found that being involved with the research project with faculty member increased the chance to earn a STEM bachelor's degree for community college transfer students. The particular finding contributes to the long-standing literature on the benefits

of undergraduate research experiences in STEM education (Bauer & Bennett, 2003; Ceglie & Settlage, 2016; Eagan et al., 2013; Hunter, Laursen, & Seymour, 2006; Kobulnicky & Dale, 2016; Lopatto, 2004; Russell, Hancock, & McCullough, 2007; Sadler, Burgin, McKinney, & Punjuan, 2010; Seymour, Hunter, Laursen, & DeAntoni, 2004). Moreover, the finding adds important empirical evidence regarding the positive impact of research experiences with faculty for students who began their postsecondary education at the community college (Hirst, Bolduc, Liotta, & Packard, 2014; Leggett-Robinson, Mooring, & Villa, 2015; Lenaburg et al., 2012; Strawn & Livelybrooks, 2012). Qualitative finding offers a reasonable explanation to why research participation contributed to STEM degree attainment for community college transfer students. Research experience facilitates academic growth, enhances STEM skills and confidence, and motivates students to pursue a graduate degree (Hirst et al., 2014). All of these qualities are crucial for STEM baccalaureate attainment.

Enriching educational practices. In this study, enriching educational practices were defined as “complementary learning opportunities in- and out-of-class augment academic programs” (Kuh, 2009, p.18). These activities contribute to knowledge integration and application (Hedrick et al., 2010). Enriching educational practices in this study included community college transfer students’ participation in study abroad opportunities, internship programs, and culminating senior experience, and volunteer services. Among these four areas, only participation in culminating senior experience was found to be a predictor of STEM bachelor’s degree completion.

Prior research has indicated a wide range of benefits that culminating senior experience provides to the students, including those studying STEM. These benefits include inquiry, knowledge building and application, resolution, design, decision-making, and problem-solving

skills, critical thinking, quantitative reasoning, teamwork, communication, information literacy, and design processes (Eppes, Milanovic, & Sweitzer, 2012; Thomas, 2010). All of these skills are acquired as a result of participating in culminating senior project and contribute to students' retention, persistence, satisfaction, and learning outcome (Kuh, 2009). Satisfaction and learning outcome, as measured by students' GPA, are closely related to students' baccalaureate attainment in STEM (Crisp et al. 2009; Ferrare & Lee, 2014; Xu 2015).

Previous literature indicated there was a positive influence of participation in the 1) internship opportunity (Piper & Krehbiel, 2015), 2) study abroad program (Roberts, Breedlove, & Strode, 2016), and 3) volunteer service (Gleason et al., 2010) on the success of STEM students. This study, nonetheless, did not identify a connection between engagement with the three aforementioned dimensions and STEM bachelor's degree attainment among community college transfer students. Results of the comparative analyses also showed that only a small portion of STEM baccalaureate completers participated in a study abroad opportunity even though a larger proportion of them did so than their non-STEM completers counterparts. In addition, both STEM BA completers and non-completers were not actively engaged with the volunteer service. Similarly, past research indicated that community college transfer students demonstrated minimal involvement with extracurricular activities including volunteer services and study abroad programs (Borglum & Kubala, 2000; Ishitani & McKittrick, 2010; Kuh's 2003; Lester, Leonard, & Mathias, 2013; Newell, 2014). The lack of engagement in these areas may be partly due to the distinctive characteristics of transfer students such as commuting to campus, working off-campus full-time, coming from lower socioeconomic households, and assuming significant family responsibilities, which all affect their availability to be engaged in activities outside of class (Lester, 2010; Office of Institutional Assessment, 2010; Tinto, 1997).

Recommendations for Policy and Practice

Being cognizant of the factors that predict the baccalaureate degree attainment in STEM of community college transfer students is pivotal in widening their representation in the STEM workforce. The results of this study shed light on a concrete educational outcome among this population, which has not been sufficiently addressed in the STEM literature. This study also contributes to the growing body of literature on successful completion of STEM baccalaureate degree in that it focused specifically on community college transfer students. To date, this student population has received an inadequate amount of attention from researchers studying STEM degree accomplishment. Moreover, the study highlighted engagement types that have often been neglected in studies of community college transfer students pursuing STEM education, such as engagement with community-based project, internship, culminating senior experience, and study abroad. The findings of this study offer a number of implications for policymakers and practitioners at both 2- and 4-year institutions.

The study demonstrated that graduation in STEM is influenced by community college transfers' high school GPA. This may indicate that students with a higher GPA are academically better prepared for college and ready to embark on a STEM trajectory and students with lower GPAs may experience more difficulties and may need additional support to navigate college in general and STEM education in particular. Thus, to promote STEM retention and baccalaureate degree attainment, community colleges may need to provide additional academic support for their incoming students who did not perform well in high school. A recommendation that Kraemer (1995) directed towards community colleges over two decades ago still presents a valid approach for faculty and practitioners to consider today. The researcher urged that "the institution should utilize several common instruments to assess the [academic] abilities of entering

students” (Kraemer, 1995, p. 317). Kraemer (1995) further noted that with an awareness of the academic potential and level of preparation of the students, “The faculty would be able to develop programs to strengthen students’ academic abilities as a step toward improving academic performance” (p. 317). In addition, Ceglie and Settlage (2014) suggested that community colleges’ effort in “hiring dedicated advisors, offering special courses, providing tutors, and creating supportive peer environments” (p. 181) could be beneficial to students in their navigation of college science.

In addition to the lack of preparation, students with low high school performance may not choose to study STEM because of low self-efficacy (Wang, 2013b, 2013c). As such, earlier on, faculty and advisors could spend time exploring students’ career interests and personal concerns regarding their career choice. Then, as part of the efforts to guide them to choose STEM, faculty who teach early STEM courses could consider adopting pedagogy that facilitates students’ STEM learning, STEM, and self-efficacy. For example, they could integrate into their teaching a problem-solving component (Hunhausen, Agarwal, Zollars, & Carter, 2008) and a direct application of acquired knowledge in real-world, hands-on STEM activities (Jonassen, Strobel, & Lee, 2006). All of these efforts could enhance self-efficacy in STEM learning and promote interest in STEM careers among community college students (Baker, Wood, Corkins, Stephen Krause, 2015), including individuals with a lower high school GPA. As noted by Baker et al. (2015), “When student self-efficacy is improved, retention and graduation rates increase” (p. 563).

Moreover, both 2-year and 4-year institutions could form a cohesive STEM learning community to foster student learning and to allow students with lower performance in high school to envision the possibility of their success in a STEM career. As recommended by Piper

and Krehbiel (2015), such an effort to form a learning community could involve field trips, receptions, and other common activities, where all students are invited to participate. Career service counselors, professionals in STEM fields, and alumni with successful careers in STEM could be invited to serve as guest speakers to provide students with insights into pathways to STEM occupations. Additionally, STEM departments could consider hosting departmental seminar presentations or STEM symposium to guide readings on the history and practices of science and technology (Piper & Krehbiel, 2015). The vigorous efforts from higher education institutions to provide students who did not perform well in high school with supplemental academic training, encouragement, support, and exposure to STEM may, hopefully, translate into students' strengthened confidence and qualification to pursue STEM degrees.

Since this study found that being Asian increased the chance of the transfer students to attain a STEM baccalaureate degree, it may be beneficial for higher education institutions to expand efforts to explore the experience of Asian community college transfer students in STEM programs. Understanding their experience may provide the baseline for understanding what academic experiences could be transferrable to the success of other racial transfer student groups in STEM fields of studies. The result may also indicate that different racial/ethnic groups may experience different challenges as they navigate their STEM education. Thus, extra support and services targeting underrepresented minorities including Black/African American, Hispanic, and other racial groups of students are of paramount importance in assisting these sub-groups of transfer students to achieve equal success in STEM education as their peers from other ethnic groups. As indicated by Jackson et al. (2013), transfer orientations, mentoring programs, undergraduate research programs, and opportunities to engage with faculty and peers are beneficial to underrepresented minorities in STEM programs.

Results of the study revealed that for community college transfer students, their 1) use of school library for coursework, 2) participation in the community project, 3) involvement in the research project with faculty, and 4) participation in a senior culminating senior experience were positively associated with their attainment of at least a bachelor's degree in STEM. While culminating senior, or capstone, course is offered at the 4-year institution (Carlson & Peterson, 1993; Gardner & Van der Veer, 1998; Murry, 1998; Tickle, Li, & Walters, 2013) and utilization of campus library represented students' experience at the community college, it is unknown where students' engagement the community-based project and research with faculty took place. Therefore, recommendations for practice regarding community-based project and research with faculty are generally directed towards both 2-and 4-year institutions.

The current study found that among community college transfers, working on coursework at the school library in the community college was positively related to graduation with a STEM degree. The finding suggests that by taking approaches to encourage the utilization of campus library for coursework purposes, community colleges might help increase STEM baccalaureate degree completion rate. Following are some practices community colleges could consider adopting to facilitate students' use of campus library.

First, during orientation, new students at community colleges may benefit from a campus tour to the library where they can learn about services and resources that the library provides. Second, STEM faculty could encourage students to pay regular visit to the library to study, (individually or in groups), and to explore educational resources that facilitate their curiosity, interest, and performance in STEM. Third, institutional investment in the training of librarians and staff and the upgrading of library facilities and resources could further promote students' use of the campus library (Subramaniam, Ahn, Fleischmann, & Druin, 2012) For example, the

students might maximize their use of the campus library for coursework once they realize that the rich library resources and knowledgeable librarians could help students complete their homework more effectively.

Besides using school library for coursework completion, transfer students' participation in the community-based project was found to positively predict their baccalaureate attainment in STEM. This finding suggests that institutions' efforts to involve students in the community-based project could promote success in STEM pursuit among community college transfer students. A first step to create a community-based project, as recommended by Keen and Baldwin (2004), is to build rapport with a community partner by reaching out to the community and identifying specific needs that knowledge and skills in STEM could address. STEM faculty members could then provide incentive for students to take part in the projects by offering credits for participation. They could also discuss with students in detail the benefits of such an educational opportunity. In addition, researchers have advocated for the practice of reflection (such as keeping a journal or creating poster presentations) (Elam, Musick, Sauer, & Skelton, 2002; Elam et al., 2003; Hunt, Bonham, & Jones, 2011) to integrate the acquired knowledge from the community-based experience. This educational practice of reflection could attract the participation of STEM students as they may find it meaningful and beneficial to their learning outcome.

The results of the study indicated that participation in research projects with faculty increases the probability of community college students earning a STEM baccalaureate degree. Thus, this study admonishes postsecondary institutions to integrate undergraduate research into the STEM curriculum (Bauer & Bennett, 2003; Craney, McKay, & Morris, 2011; Foertsch, Alexander & Penberthy, 2000; Gilmore, Vieyra, Timmerman, Feldon, & Maher, 2015; Hunter et

al., 2007; Jones, Barlow, & Villarejo, 2010; Kardash, 2000; Nagda, Gregerman, Jonides, Von Hippel, & Lerner, 1998; Russell et al., 2007; Seymour et al., 2004; Summers & Hrabowski, 2006; Thiry, Laursen, & Hunter, 2011). Specifically, faculty might offer course credits for participation in research projects. Gilmore et al., (2015).

Ideally, 2-year institutions would incorporate research projects directly into their curriculum to provide a research experience for their students. Unfortunately, at the community college, limited research activities take place (Cohen, Brawer, & Kisker 2014). This is partly because faculty often lack institutional support to execute a research activity or to seek an opportunity to initiate a research project (Hirst et al., 2014). As a result, this study joins previous researchers in calling for the formulation and strengthening of partnerships and collaboration between 2-and 4-year institutions to create summer bridge research opportunities for community college students studying in STEM fields. Such programs would allow community college students to gain research experience to further enhance their STEM skills and facilitate their persistence (Hirst et al., 2014; Leggett-Robinson et al., 2015; Lenaburg et al., 2012; Strawn & Livelybrooks, 2012).

Additionally, encouragement, motivation, and support should be rendered directly to STEM faculty, both at 2-and 4-year institutions, so they can generate research opportunities for students and be willing to serve as their mentors or supervisors. Kobulnicky and Dale (2016) suggested that “although intellectual capital is sufficient motivation for some faculty, a small summer stipend may be required to ensure the active participation” (p.21).

Lastly, this current study found that having culminating senior experience increases the chance that the community college transfer student would obtain a baccalaureate degree in STEM. The finding implies that mandating enrollment in the culminating senior course as part of

the degree requirement for STEM students might present a feasible strategy to promote students' graduation with a STEM degree. Additionally, at the community college, faculty and advisor may extend efforts to inform and discuss with their students the culminating senior experience offered at the 4-year institution. Knowledge about such opportunities and offerings in advance while still enrolling at the community college would help STEM students to better plan for their academic journey.

Recommendation for Future Research

As noted by Svanum and Bigatti (2009), "Engaged students are more likely to earn a degree, do it faster, and do it better" (p.120). Understanding the engagement of community college transfer students is pivotal to developing strategies to increasing the STEM graduation rate, hence, increasing the representation of this important group of learners in STEM professions. This increase is critical in responding to the heightening demand for a skilled, educated STEM workforce. This dissertation study presents one of the first efforts to investigate the college engagement of community college transfer students in relationship to their STEM baccalaureate completion. To expand this line of important inquiry, researchers could consider the following suggestions.

In examining the relationship between race and STEM degree attainment, the current study chose White students as a reference group and found that Asian students were more likely to achieve the degree. Future studies with a focus on race could explore the differences in the experience and STEM performance of community college transfer students based on the students' race/ethnicity. Such an endeavor could potentially help identify a struggle of a particular racial or ethnic group that needs attention and support from higher education institutions to flourish in their STEM pursuit.

Further investigation to understand the factors that inhibit community college transfer students with low high school GPA from earning a STEM degree is warranted. For example, a question worth considering is how high school performance is related to students' self-efficacy, STEM interest, and their ability to be admitted into STEM programs. An answer to this question would benefit community college and 4-year institutions in identifying appropriate strategies and implementing support programs to narrow the achievement gap in STEM education between those with precollege academic deficit and their higher-achieving peers.

This current study focused solely on community college transfer students and did not examine students who started directly at a 4-year university. Wang (2015) indicated that community college transfer students graduate with a STEM bachelor's degree at a lower rate than their peers who started at 4-year institutions. Additionally, empirical evidence has demonstrated a lower level of engagement among community college transfer students compared to students beginning at the 4-year universities (Borglum & Kubala, 2000; Ishitani & McKittrick, 2010; Kuh's 2003; Lester et al., 2013; Newell, 2014). However, these studies do not explore how differences in engagement could potentially affect differences in academic outcome, particularly STEM baccalaureate degree attainment. Thus, future research could examine the experiences of both groups of students pursuing STEM–community college transfers and native students at the 4-year institutions. This inquiry is critical in furthering the understanding of variations in precollege backgrounds and college engagement between two groups of college attendees and how these characteristics contribute to their completion of a bachelor's degree in STEM across both groups. Knowledge should be advanced in understanding why math and science precollege preparation exerts stronger influence on STEM choice and baccalaureate attainment for native students at the 4-year institution than it does for community college transfer students. The

extended knowledge of the background and college experiences of community college transfers against those of native students at 4-year universities could provide direction for higher education institutions in developing policies to support transfer students in catching up with their peers in earning a STEM undergraduate credential.

This study offers some primary empirical evidence regarding the association between some engagement factors (i.e. utilization of school library for coursework, participation in community-based project, involvement in the research project with faculty, and culminating senior experience) and STEM degree attainment among community college transfers. Future qualitative studies would deepen the understanding of the engagement of community college transfers within each of those areas. The knowledge obtained from in depth qualitative inquiries would contribute further to the development and implementation of policies and practices that effectively promote transfer students' success in their STEM studies. Moreover, specific insight into where a certain experience takes place (i.e., at the community college or the 4-year institution) could help the researchers in offering proper recommendations to the relevant educational entity.

To further advance the knowledge regarding engagement of community college transfer students, longitudinal studies could consider following a cohort of students beginning at a community college, rather than at high school, to more fully capture the nuanced experiences of a more representative population of community college beginners. This population could include those who entered higher education at later time in their lives and students who only joined the American educational system at the college level. For example, a question worthy of the exploration could be: Do interactions with faculty and advisors affect STEM interest and persistence differently for traditional-age and non-traditional age community college students?

Also, since community college beginning students often possess distinctive characteristics, future research should take into consideration some external demands the students experience while navigating college such as, work status (full-time, part-time; on-campus, off-campus), family status, enrollment status (full-time, part-time); or financial aid receipt. All of these factors were not considered in the present study, yet, understanding their influence and impact on students' educational attainment would help both community colleges and 4-year institution to work on specific strategies to allay financial concern, provide academic support, and better promote transfer students' eventual success in their STEM education.

Finally, when examining the pathways to STEM degree attainment, students' major choice should be taken into consideration. Such an approach to the inquiry would advance the understanding of factors associated with STEM attrition and retention among community college transfers who do possess initial interest and intention to pursue STEM. This understanding is important in adopting practices to retaining transfer students with STEM aspiration.

Conclusion

The purpose of this dissertation was to investigate the relationship between precollege background and college engagement of community college transfer students and their baccalaureate degree attainment in STEM fields. The study revealed an association between some background, precollege characteristics, and college engagement factors and students' successful attainment of a STEM degree at the baccalaureate level and above. Overall, the study found that Asians were more likely to obtain the degree than their White peers; and the higher GPA the transfer students achieved, the better chance they had in earning the STEM degree. In addition, students' utilization of campus library for their coursework and their participation in 1) the community-based project, 2) research opportunity with a faculty member, and 3) culminating

senior experience all positively predicted their graduation from a 4-year institution with a STEM degree.

Examining the transfer pattern falls outside the parameter of the current study. However, given that Black/African American and Hispanic students were overrepresented in the community college and a large proportion aspire to transfer and earn a baccalaureate degree (Ma & Baum, 2015), their much lower rate of representation compared to White students in the transfer sample of the current study raises questions about the transfer function of the community college. Because community colleges have long been the institution of choice for underrepresented minorities, including Black/African American and Hispanic students, to obtain a baccalaureate degree through a transfer route, the function of the community college in charting a transfer pathway for these groups of students need to be reexamined. The promotion of transfer, and subsequently baccalaureate graduation rates, among these underrepresented minorities through the adoption of special support programs, is highly critical in addressing diversity and social equity in education. Only by attending to the educational needs and aspiration of these historically marginalized groups and providing them with sound services to assist them in the achievement of their educational goals, can the community college truly represent an effective alternative path to higher education and maximize its function in building a future of high quality and diversified workers.

As the community college transfer students will continue to contribute to the graduation rate in STEM baccalaureate education, faculty, administration, and professionals working at institutions of higher education should be better equipped with knowledge and skills in engaging this crucial population in a wide array of activities conducive to their success in STEM. The role of college engagement in transfer students' success in STEM education and career development

warrants more attention in future research. Researchers should take further empirical efforts to improve the educational experiences of this group of students in order to contribute to strengthening the quality of STEM pool of employees.

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APPENDIX A: LIST OF VARIABLES AND RECODED VARIABLES

Original variable	Values	Measure	Recoded variable	Values	Measure	Survey Question
INPUT						
F1SEX (Gender)	1=Male; 2=Female	Nominal	F1SEX_RECODED (Gender)	0=Male; 1=Female	Nominal	
F1RACE (student's race/ethnicity-composite)	1= Amer. Indian/Alaska Native, non-Hispanic 2= Asian, Hawaii/Pac. Islander, non-Hispanic 3= Black or African American, non-Hispanic 4= Hispanic, no race specified 5= Hispanic, race specified 6= More than one race, non-Hispanic 7= White, non-Hispanic	Nominal	F1RACE_RECODED1 (Ethnicity) <i>Used for descriptive and comparative analyses</i>	1= Amer. Indian/Alaska Native, non-Hispanic 2= Asian, Hawaii/Pac. Islander, non-Hispanic 3= Black or African American, non-Hispanic 4= Hispanic 6= More than one race, non-Hispanic 7= White, non-Hispanic	Nominal	

Original variable	Values	Measure	Recoded variable	Values	Measure	Survey Question
			F1RACE _RECODED (Ethnicity) <i>Used for logistic regression analysis</i>	1= White, non-Hispanic 2= Asian, Hawaii/Pac. Islander, non-Hispanic 3= Black or African American, non-Hispanic 4= Hispanic 6= Multiracial & American Indian	Nominal	
F1SES1QU (F1 quartile coding of SES1 variable)	_8=legitimately skip 1= Lowest quartile 2= Second quartile 3= Third quartile 4= Highest quartile	Scale				
F1RGPP2 (GPA for all courses taken in the 9th - 12th grades - categorical)	_9=Missing _4=Nonrespondent "0= 0.00 - 1.00 1= 1.01 - 1.50 2= 1.51 - 2.00 3= 2.01 - 2.50 4= 2.51 - 3.00 5= 3.01 - 3.50 6= 3.51 - 4.00"	Scale	F1RGPP2_HSGPA (High school GPA)	"0= 0.00 - 1.00 1= 1.01 - 1.50 2= 1.51 - 2.00 3= 2.01 - 2.50 4= 2.51 - 3.00 5= 3.01 - 3.50 6= 3.51 - 4.00" (_9=_9; _4=_9; _9 labeled as missing)	Scale	

Original variable	Values	Measure	Recoded variable	Values	Measure	Survey Question
F2B17A (High school math prepared for first postsecondary school)	_9=Missing _8=Survey component legitimate skip _4=Nonrespondent _3=Item legitimate skip/NA 1=not at all 2=somewhat 3=a great deal	Scale	F2B17A _MATHPREP (High school math prepared for first postsecondary school)	1=not at all 2=somewhat 3=a great deal (_9; _8; _4; _3 =_9; _9 labeled as missing)	Scale	To what extent did High school math courses prepare you for [F2PS1-first postsecondary institution]? Would you say not at all, somewhat, or a great deal? 1 = Not at all; 2 = Somewhat; 3 = A great deal; 4 = Did not take in high school
F2B17B (High school science prepared for first postsecondary school)	_9=Missing _8=Survey component legitimate skip _4=Nonrespondent _3=Item legitimate skip/NA 1=not at all 2=somewhat 3=a great deal	Scale	F2B17B _SCIENCEPREP (High school science prepared for first postsecondary school)	1=not at all 2=somewhat 3=a great deal (_9; _8; _4; _3 =_9; _9 labeled as missing)	Scale	To what extent did High school science courses prepare you for [F2PS1-first postsecondary institution]? Would you say not at all, somewhat, or a great deal? 1 = Not at all; 2 = Somewhat; 3 = A great deal; 4 = Did not take in high school
ENVIRONMENT						
Active Learning Experiences						
F2B18C (Work on coursework at school library)	_9=Missing _8=Survey component legitimate skip _4=Nonrespondent _3=Item legitimate skip/NA 1=Never 2=Sometimes 3=Often	Scale	F2B18C_LIBRARY	1=Never 2=Sometimes 3=Often (_9; _8; _4; _3 =_9; _9 labeled as missing)	Scale	During the time that you [have been/were] enrolled at [F2PS1-first postsecondary institution], how often [have/did] you [worked/work] on coursework at your school library? 1 = Never; 2 = Sometimes; 3 = Often

Original variable	Values	Measure	Recoded variable	Values	Measure	Survey Question
F2B18D (Use the web to access school library for coursework)	_9=Missing _8=Survey component legitimate skip _4=Nonrespondent _3=Item legitimate skip/NA 1=Never 2=Sometimes 3=Often	Scale	F2B18D_WEB	1=Never 2=Sometimes 3=Often (_9; _8; _4; _3 =_9; _9 labeled as missing)	Scale	During the time that you [have been/were] enrolled at [F2PS1-first postsecondary institution], how often [have/did] you [used/use] the web to access your school library for coursework? 1 = Never; 2 = Sometimes; 3 = Often
F3A14D (High-impact PS activities: Community-based project)	_9=Missing _8=Survey component legitimate skip _7=Not administered; abbreviated interview or breakoff _4=Nonrespondent _3=Item legitimate skip/NA 0=No 1=Yes	Scale	F3A14D_COMMUNITY BASED	0=No 1=Yes (_9; _8; _7; _4; _3 =_9; _9 labeled as missing)	Scale	Question wording: [Have you participated/Did you participate] in Community-based project (for example, service learning) as part of a regular course as a part of your [undergraduate/college] education? 1=Yes; 0=No
F3A14F (High-impact PS activities: Mentoring)	_9=Missing _8=Survey component legitimate skip _7=Not administered; abbreviated interview or breakoff _4=Nonrespondent _3=Item legitimate skip/NA 0=No 1=Yes	Scale	F3A14F_MENTORING	0=No 1=Yes (_9; _8; _7; _4; _3 =_9; _9 labeled as missing)	Scale	Question wording: [Have you participated/Did you participate] in Program in which you were mentored as part of a regular course as a part of your [undergraduate/college] education? 1=Yes; 0=No

Original variable	Values	Measure	Recoded variable	Values	Measure	Survey Question
Interactions with Faculty and Advisor						
F2B18A (Talk with faculty about academic matters outside of class)	_9=Missing _8=Survey component legitimate skip _4=Nonrespondent _3=Item legitimate skip/NA 1=Never 2=Sometimes 3=Often	Scale	F2B18A _FACULTY	1=Never 2=Sometimes 3=Often (_9; _8; _4; _3 =_9; _9 labeled as missing)	Scale	During the time that you [have been/were] enrolled at [F2PS1-first postsecondary institution], how often [have/did] you [talked/talk] with faculty about academic matters outside of class time? 1 = Never; 2 = Sometimes; 3 = Often
F2B18B (Meet with advisor about academic plans)	_9=Missing _8=Survey component legitimate skip _4=Nonrespondent _3=Item legitimate skip/NA 1=Never 2=Sometimes 3=Often	Scale	F2B18B _ADVISOR	1=Never 2=Sometimes 3=Often (_9; _8; _4; _3 =_9; _9 labeled as missing)	Scale	During the time that you [have been/were] enrolled at [F2PS1-first postsecondary institution], how often [have/did] you [met/meet] with your advisor concerning academic plans? 1 = Never; 2 = Sometimes; 3 = Often
F3A14B (High-impact PS activities: Research project with faculty member outside course/program requirements)	_9=Missing _8=Survey component legitimate skip _7=Not administered; abbreviated interview or breakoff _4=Nonrespondent _3=Item legitimate skip/NA 0=No 1=Yes	Scale	F3A14B _RESEARCH	0=No 1=Yes (_9; _8; _7; _4; _3 =_9; _9 labeled as missing)	Scale	Question wording: [Have you participated/Did you participate] in Research project with a faculty member outside of course or program requirements as a part of your [undergraduate/college] education? 1=Yes; 0=No

Original variable	Values	Measure	Recoded variable	Values	Measure	Survey Question
Enriching Educational Practices						
(F3A14A High-impact PS activities: Internship/co-op/field experience/student teaching/clinical assignment)	_9=Missing _8=Survey component legitimate skip _7=Not administered; abbreviated interview or breakoff _4=Nonrespondent _3=Item legitimate skip/NA 0=No 1=Yes	Scale	F3A14A _INTERNSHIP	0=No 1=Yes (_9; _8; _7; _4; _3 =_9; _9 labeled as missing)	Scale	Question wording: [Have you participated/Did you participate] in Internship, co-op, field experience, student teaching, or clinical assignment as a part of your [undergraduate/college] education? 1=Yes 0=No
F3A14C (High-impact PS activities: Study abroad)	_9=Missing _8=Survey component legitimate skip _7=Not administered; abbreviated interview or breakoff _4=Nonrespondent _3=Item legitimate skip/NA 0=No 1=Yes	Scale	F3A14C _STUDYABROAD	0=No 1=Yes (_9; _8; _7; _4; _3 =_9; _9 labeled as missing)	Scale	Question wording: [Have you participated/Did you participate] in Study abroad as a part of your [undergraduate/college] education? 1=Yes; 0=No
F3A14E (High-impact PS activities: Culminating senior experience)	_9=Missing _8=Survey component legitimate skip _7=Not administered; abbreviated interview or breakoff _4=Nonrespondent _3=Item legitimate skip/NA 0=No; 1=Yes	Scale	F3A14E _CULMINATING	0=No 1=Yes (_9; _8; _7; _4; _3 =_9; _9 labeled as missing)	Scale	Question wording: [Have you participated/Did you participate] in Culminating senior experience, such as a capstone course, senior project or thesis, or comprehensive exam as a part of your [undergraduate/college] education? 1=Yes; 0=No

Original variable	Values	Measure	Recoded variable	Values	Measure	Survey Question
F2D11 (Frequency of volunteer service)	_9=Missing _8=Survey component legitimate skip _7=Not administered; abbreviated interview or breakoff _4=Nonrespondent _3=Item legitimate skip/NA 1= Less than once a month 2 = At least once a month but not weekly 3 = At least once a week	Scale	VOLUNTEER (Derived from F2D11)	_3=0= No participation 1= Less than once a month 2 = At least once a month but not weekly 3 = At least once a week (_9=_9; _8=_9; _7=_9; _4=_9; _9 labelled as missing)	Scale	During the past two years, how often did you spend time volunteering or performing community service? 1 = Less than once a month; 2 = At least once a month, but not weekly; 3= At least once a week
OUTPUT						
F3TZHIGHDEG Transcript: Highest known degree attained as of June 2013	_9=Missing _8=Survey component legitimate skip _4=Nonrespondent _3=Item legitimate skip/NA 1= certificate or diploma; 2= Associate’s degree; 3= Bachelor’s degree; 5= Master’s degree; 7= Doctoral degree	Scale				

Original variable	Values	Measure	Recoded variable	Values	Measure	Survey Question
F3TZSTEM2CRED Transcript: Ever earned a postsecondary credential in a STEM field as of June 2013 (NSF grant definition)	_9=Missing _8=Survey component legitimate skip _7=Not administered; abbreviated interview or breakoff _4=Nonrespondent _3=Item legitimate skip (no PS cred _2=Refused _1=Don't know 0 = No PS cred in a STEM field 1= Undergraduate cred in a STEM field = UG and graduate cred or graduate only cred in a STEM field"	Scale	STEM _ATTAINMENT (STEM Baccalaureate attainment)	0=STEM BA non-completer 1=STEM BA completer	Nominal	