AN EXAMINATION OF THE ROLE OF COLLEGE-LEVEL MATHEMATICS IN STEM MAJOR PERSISTENCE

by

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Jaimi Kathleen Paschal
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AN EXAMINATION OF THE ROLE OF COLLEGE-LEVEL MATHEMATICS IN STEM MAJOR PERSISTENCE

Abstract

The purpose of this study was to examine the association between first-term college-level mathematics course and STEM major persistence. The study utilized data from a medium-sized, 4-year, open access, public institution on the West Coast of the United States. The data consisted of students enrolled at the institution of study between the Fall 2008 and Fall 2013 terms who declared STEM majors at matriculation. Decreasing logistic regression was used to identify significant variables likely to increase in a student's persistence in a STEM major through their sixth college term. Findings indicated that students with a high school GPA of 3.00 or higher and students who passed a first-term college-level mathematics course were at significantly greater odds of being retained.

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California State University, Fresno

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Dear thanks to my husband, who supported me through the ups and downs, singlehandedly kept the house clean, and never hesitated to hug me when I needed it most. Who listened, remained patient and steadfast, and kept me balanced. And to my daughter, to whom I hope this act of obtaining a terminal degree encourages her to reach for the stars. Her ability to always make me see the bright side of things through laughter, positive texts, and celebration of our time together were a huge encouragement.

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CHAPTER 1: INTRODUCTION

This chapter introduces a quantitative research study that explored the role of first-term college-level mathematics courses on long-term science, technology, engineering, and mathematics (STEM) major persistence. This study aimed to identify previously undiscovered variables that predict persistence in STEM majors. The following section provides background information on the topic of the study, the statement of the problem, the purpose of the study, the significance of the study, the theory guiding the study, and definitions of key terms used throughout the study.

Background

The return on investment for completing a college degree has continued to significantly influence wage earnings over those not completing a college degree (Luthra & Flashman, 2017). The drive to participate in today's global economy as the means to shift socioeconomic brackets (Peercy & Svenson, 2016) has led to ever-increasing enrollments in postsecondary educational institutions worldwide (Aud et al., 2012). Participation in postsecondary education helps train future leaders, expand minds, nurture creativity, create economic growth, and reduce poverty (Peercy & Svenson, 2016).

In the United States, college enrollment in undergraduate degree programs has increased dramatically from 12.7 million students in Fall 1999 to roughly 20 million students in Fall 2015 (National Center for Education Statistics, 2015a). However, despite increased enrollment, student persistence to degree completion continues to be a challenge facing higher education institutions. This is evidenced in data from the National Center for Education Statistics (2015b, 2017), which states that 6-year graduation rates have remained at 59% for students entering

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college from 2005 through 2009. In addition, students enrolled at public, open-access universities see the lowest graduation rates compared to restrictive-access public and private universities (National Center for Education Statistics, 2017).

Further, more than 80% of undergraduate students attending a public college or university are considered non-traditional students (e.g., first generation, having dependents, employed, or attending college part-time) (Ross-Gordon, 2011; Soria & Stebleton, 2012). Due to the unique and varied backgrounds of non-traditional students, it is often difficult for higher education institutions to implement initiatives and student support services that fulfill the needs of the entire population. In fact, one research study found that approximately 60% of first-generation students who drop out of college do so in their first year (Jaeger & Eagan, 2010).

In addition to calling for an increase in the number of graduates in STEM fields, a 2012 report by the President's Council of Advisors on Science and Technology called on U.S. postsecondary institutions to launch initiatives to combat mathematics preparedness gaps between underrepresented minority students and their White and Asian peers, to address national trends on preparedness gaps. For example, a National Center for Education Statistics report indicated that White students often obtain higher mathematics scores in the 12th grade than their Black and Hispanic peers (Musu-Gillette et al., 2016).

As college retention rates plateau, schools find themselves subject to public scrutiny. Currently, public postsecondary educational institutions are funded primarily on student tuition, thus driving increased admission rates while simultaneously requiring universities to work on retaining students to secure funding (Kiley, 2012). Retention has financial benefits to both the students and the institutions. College costs for students have risen more than 1,000% in the last

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30 years (Johnson, Van Ostern, & White, 2012); therefore, students who complete a college degree in a timely manner should be more likely to have less debt upon graduation. For institutions of higher education, retaining students saves money by reducing recruitment costs (Garrett & Poock, 2011), as it is estimated that states lose up to $730 million in tax revenue due to student dropouts from a single cohort (Johnson, N, 2012).

While research has identified multiple variables contributing to success in STEM disciplines, to date, the role of first-term college-level mathematics placement, mathematics course, and subsequent grade earned has not been explored as a predictor of STEM persistence through the sixth quarter term of college, or in other words, the end of a student's second year in college. Therefore, this study aims to do so.

Statement of the Problem

Of the more than 20 million students entering an American community college or university in Fall 2015 (National Center for Education Statistics, 2017), 5.2 million entered 4-year institutions as STEM majors (Chen & Soldner, 2014). STEM majors made up roughly 18% of the 1.7 million bachelor's degrees awarded in 2009-2010 (National Center for Education Statistics, 2015b). Students who major in STEM disciplines, like most other students, enter college with an intended major but often change their minds and graduate in a different discipline (Griffith, 2010). It is estimated that close to 50% of students that declare a STEM major within their first year of postsecondary education leave prior to obtaining a STEM degree (Chen & Soldner, 2014). Of these students, 30% switch to a non-STEM major and 20% drop from the institution (Chen & Soldner, 2014).

In addition, a significant portion of STEM degrees awarded appear to be going to international students who return to their home countries, leaving

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domestic employment positions unfilled (McGrath et al., 2013). Moreover, there has been recent increased attention on STEM education at a national level. For example, the 2012 report by the President's Council of Advisors on Science and Technology called for an increase of 1 million college graduates in STEM disciplines to combat the United States' government job shortage forecast for the next 10 years (Iammartino, Bischoff, Willy, & Shapiro, 2016). Additionally, Carnevale, Smith, and Strohl's (2013) report on workforce recovery in the U.S., after the 2007 recession, suggested that institutions need to increase graduation rates of STEM majors to fill four million current jobs in high-demanding STEM fields with vacancies.

Moreover, although the 1990s saw the beginning of the number of college degrees obtained by women pass the number obtained by men (National Center for Education Statistics, 2015b), women pursue and graduate in STEM majors at a much lower rate than men (National Center for Education Statistics, 2015b; Tinto & Pusser, 2006), despite indicating a higher interest in STEM disciplines than men at an early age (Perry, Link, Boelter, & Leukefeld, 2012). Students from underrepresented minority groups and those from low socioeconomic backgrounds also graduate at significantly lower rates in STEM disciplines than their peers from non-underrepresented minority groups and those from middle- and high-socioeconomic backgrounds (National Center for Education Statistics, 2015b). Additionally, underrepresented minorities are not well represented in STEM gateway courses like calculus, with 81% of students taking calculus identifying as White (Bressoud, Mesa, & Rasmussen, 2015).

As the focus on STEM major completion increases, the need to determine factors that contribute to success in STEM disciplines becomes more critical. There is a need to study the role of entry-level college-level mathematics courses

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that act as gatekeeper courses in most STEM disciplines. For instance, at least one calculus-level course is required for most STEM degrees; however, calculus also acts as a barrier to STEM major persistence for many students (Bressoud et al., 2015). This study aimed to add to the literature by analyzing the role of first-term college-level mathematics placement, course, and grade as a predictor of STEM persistence through the sixth term of college.

Purpose of the Study

The purpose of this observational, quantitative study was to examine the relationship between mathematics course-taking in the first term of college and college student persistence in STEM majors. First-term college-level mathematics course-taking was determined by whether a student passed, did not pass, or did not take a first-term college-level mathematics course. A student's persistence in STEM majors was established by comparing a student's declared major at matriculation and their declared major at the end of their sixth college term. The predictor variables under study included gender, ethnicity, socioeconomic status, high school GPA, college mathematics placement, and first-term college-level mathematics course taking. The study sought to answer the following research questions:

1. Are there differences between the characteristics of college students who do and do not persist in STEM majors to the sixth college term?
2. What is the contribution of demographic variables, pre-college variables, and college variables to persistence in STEM majors to the sixth college term?

Logistic regression was used to analyze the data. This method was deemed appropriate to answer the research questions because the study involved a dichotomous dependent variable and multiple independent variables (Hosmer,

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Lemeshow, & Sturdivant, 2013). The predictor variables were chosen after a review of the current research literature on STEM retention.

Significance of the Study

Declining graduation rates are a significant problem for colleges and universities in the U.S.; therefore, a study of the role of first-term college-level mathematics placement, course, and grade is important to researchers and practitioners for various reasons. First, the need to determine the reasons contributing to student attrition is widely recognized by college communities (Stinebrickner, & Stinebrickner, 2013) that face declining graduation rates. Among the growing number of students enrolling in college, a large portion of them will begin their first year in remedial mathematics (Bahr, 2011). While there is research that states these students can ultimately be successful in obtaining a degree (Bahr, 2011), there is very little research on the effect of mathematics course placement, between remedial mathematics and calculus, and subsequent grade earned, have on long-term STEM major retention. A body of research has been dedicated to the impact of mathematics remediation (Bahr, 2011) and calculus (Bressoud et al., 2015) on STEM student retention and graduation. However, no research to date has looked specifically at the role of first-term college-level mathematics placement, course, and grade on STEM persistence through the sixth term of college.

Next, by analyzing the role a first-term college-level mathematics course plays in long-term STEM student retention, educational leaders can develop interventions and supports to increase the retention of college students in STEM majors and help students graduate in STEM disciplines at higher rates. Most importantly, the findings will benefit students pursuing STEM degrees, as a study such as this can help institutions of higher education to better understand the role a

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first-term mathematics course has on long-term STEM persistence. This would allow colleges and universities to implement policies and practices to better ensure the success and retention of students majoring in STEM disciplines.

Theory

The development of the present study was guided by achievement goal theory. Achievement goal theory posits that student motivation is driven by (1) an individual's aspiration to achieve specific results, (2) an individual's belief in her or his capabilities to achieve goals, or (3) both an individual's aspiration to achieve specific results and an individual's belief in her or his capabilities to achieve goals (Nugent, 2013). Harackiewicz, Barron, Tauer, and Elliot (2002) used achievement goal theory as the theoretical framework in their examination of the retention rates of declared STEM majors from their first to fourth semesters in college. They argued that completing a gateway course in a student's declared major, such as pre-calculus for STEM majors, is comparable to an achievement goal because completion of the initial goal (i.e., the gateway course) prompts increased motivation to attain the subsequent achievement goal (i.e., the successive group of courses in the major). Harackiewicz et al. (2002) described students' experiences of completing a gateway course as:

> …a critical determinant of their motivation and performance in later courses in that discipline. Thus, we would expect that the effects of goals on long-term outcomes could be mediated through short-term outcomes. For example, we might expect mastery goals to predict continued interest in psychology and majoring in psychology because they promote interest in the topics covered in the introductory course. (p. 564)

Flanders (2015) also used achievement goal theory to examine students' efforts to graduate based on completion of a STEM major gateway course. In the current study, it was assumed that students who begin college as declared STEM majors have set achievement goals for themselves. Therefore, completing a

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gateway course is a short-term goal that students must complete to advance to their next set of short-term goals, such as registering for more STEM courses in their major pathway, which signals persistence in a STEM major. Harackiewicz et al. (2002) attested that course completion is an achievement in proving subject mastery as students pursue their goal of obtaining a 4-year degree. Thus, achievement goal theory provides a lens from which to examine why students may persist in STEM majors after completing gateway STEM courses.

Definitions of Terms

Advanced Placement (AP): A rigorous set of courses created by The College Board and offered at numerous high schools in the United States (The College Board, n.d.). Upon the completion of an AP course, a student has the option of taking an exam. A minimum score on this exam may allow the student to claim college credit in an articulated course

American College Test (ACT): A scholastic test given to high school students to test their scholastic aptitude in various subjects (ACT, 2017). The ACT is a required entrance exam at many U.S. colleges and universities.

Attrition: The act of students leaving a postsecondary institution before degree completion (Johnson, N, 2012).

Calculus I (college): Topics include introduction to differential calculus of elementary functions with an emphasis on limits, continuity, and application of differentiation.

Calculus II (college): Topics include an introduction to integral elementary functions, techniques and application of integration, The Fundamental Theorem of Calculus, improper integrals, sequences and series.

Calculus (high school): Topics include definition and graphing value of functions, application of value theorems, definitional understanding of the

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derivative of a function, understanding of the chain rule, higher order computation, basic knowledge of Rolle's theorem, mean value theorem, and L'Hopital's rule, including trigonometric functions, working knowledge of improper integrals (California Department of Education, 2015).

Enrollment: A process in which a matriculated student is placed in coursework for their major.

Entry Level Math Exam (ELM): A placement exam, created by the California State University Chancellor's office, given prior to university enrollment, which determines the mathematics course in which a student should be enrolled (Vandement, 1986).

First-generation student: Encompasses any student whose parents or guardians, as well as previous generations of parents or guardians, have not attended college in their lifetime (Woosley & Shepler, 2011).

Hispanic Serving Institution (HSI): A U.S. institution that has an undergraduate full-time student enrollment of at least 25% Hispanic students (Department of Education, n.d.a)

Major retention: The act of a student remaining in the same major he or she declared at college matriculation (Tinto & Pusser, 2006).

Matriculation: A process in which a student is formally enrolled at a postsecondary institution.

Open access postsecondary institution: An institution that accepts all applicants that meet the minimum admission requirements (National Center for Education Statistics, 2017).

PELL grant: Federal monies offered to students, enrolled in postsecondary institutions, that does not require repayment (Department of Education, n.d.b).

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Persistence: The percentage of students who maintain enrollment at any postsecondary institution (National Center for Education Statistics, 2009).

Public postsecondary institution: An institution that is operated by an elected public official and whose major funding source is public funds (National Center for Education Statistics, n.d.).

Private postsecondary institution: An institution that is operated by a privately elected official and whose major funding source is from private entities (National Center for Education Statistics, n.d.).

Remediation: Levels of mathematics and/or English courses that are below college level (Bahr, 2008).

Restricted access postsecondary institution: An institution that does not select all applicants but specifies admission criteria that restricts the number of students selected (National Center for Education Statistics, 2017).

Retention: An institutional measure of a student maintaining enrollment at the first postsecondary institution attended (National Center for Education Statistics, 2009).

Scholastic Aptitude Test (SAT): A test, created by The College Board, given to high school students to assess their aptitude in various subjects (The College Board, 2017). The SAT is a required entrance exam at many U.S. colleges and universities.

Scholastic Aptitude Test-Subject Math (SAT-M): A test, different than the comprehensive SAT, created by The College Board and given to high school students to assess their aptitude in the subject of mathematics (The College Board, 2017).

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Statistics (college): Topics include sample data descriptions, exploratory data analysis, elementary probability, distributions, estimation and hypothesis testing techniques, linear regression and correlation.

Statistics (high school): Topics include probability problems, definition and use of conditional probability, discrete random variables, continuous random variables, mean of and variance of discrete random variables, ability to determine mean and the standard deviation of normally distributed random variables, least squares regression fit, correlation coefficient of two variables, organization and distribution of data using frequency tables, histograms, standard line graphs, scatterplots, and box-and-whisker plots, confidence intervals determination, p-value, and chi-square distributions (California Department of Education, 2013).

STEM: Disciplines within science, technology, engineering, and mathematics.

Term (quarter term): The unit of measurement for course-taking within an academic calendar year at a postsecondary institution. The institution profiled in this study offers three quarters (not including a summer quarter) each academic year. This study examines STEM major retention through the sixth term, operationally defined as the end of a student's second college year.

Underrepresented Minority (URM) students: Students who identify as being of any race that is not White or Asian (Department of Education, n.d.).

Summary

This chapter provided background information on the topic of the study, the statement of the problem, the purpose of the study, the significance of the study, the theory guiding the study, and definitions of key terms used throughout the study. The following chapter will present the context of the study by reviewing the literature pivotal to retention research. Chapter 3 will outline the research

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methods of the study, Chapter 4 will detail the research findings, and Chapter 5 will include a discussion of the findings, including implications for scholars and practitioners and directions for future research.

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CHAPTER 2: REVIEW OF THE LITERATURE

This chapter contains (1) an overview of the scholarly research on college student retention in general, (2) a review of the variables associated with retention specifically for STEM majors, and (3) an examination of the research on contributors to success in mathematics for STEM majors. Each of the subsections will be examined in relation to demographic, pre-college, and college variables.

General College Student Retention

Due to the quantity and complexity of causes for student attrition and retention (Honken & Ralston, 2013), a significant amount of research has been dedicated to understanding why students leave college before degree completion (e.g., Allen & Robbins, 2008; Nguyen, Williams, & Ludwikowski, 2016; Petty, 2014; Stinebrickner & Stinebrickner, 2013). Previous research has found that factors positively correlated with college persistence include demographic variables (e.g., D'Lima, Winsler, & Kitsantas, 2014; Shaw & Barbuti, 2010; Xu, 2015), pre-college variables (e.g., Crisp, Nora, & Taggart, 2009), and college variables (e.g., Bressoud et al., 2015; Carlone & Johnson, 2007; Flanders, 2015; Kassaee & Rowell, 2016; Lane, 2016; Morganson, Major, Streets, Litano, & Meyers, 2015; Ortiz, & Sriraman, 2015; Reyes, 2011; Stanford, Rocheleau, Smith, & Mohan, 2015), each of which will be discussed below.

Demographic Variables

Previous research has identified multiple demographic variables contributing to overall college student retention, including (1) race/ethnicity, (2) first-generation status, and (3) socioeconomic status (SES). Concerning race/ethnicity, statistics have shown that college enrollment for White students has outpaced that of their Underrepresented Minority (URM) peers (President's

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Council of Advisors on Science and Technology, 2012) despite an increase in URM students over the last 10 years (Musu-Gillette et al., 2016). Additionally, students from URM groups continue to have lower retention rates than students from non-URM groups (Musu-Gillette et al., 2016). However, when controlling for academic background, research has shown that this gap all but disappears (Griffith, 2010). Despite this research finding, data indicated that the percent of White and Asian students completing undergraduate degrees far exceeds those from other ethnic groups (Musu-Gillette et al., 2016).

Similarly, SES and first-generation status appear to correlate with student persistence. Open access, 4-year universities see the achievement gap present for low-SES and first-generation college students, with both groups enrolling in public 2- and 4-year institutions at a higher rate than in 4-year private universities (Aud et al., 2012). These groups have been identified as less academically equipped when controlling for social and academic capital than continuing-generation students (Atherton, 2014; Soria & Stebleton, 2012). Further, literature suggests that approximately 60% of students who drop out of college do so in their first year (Jaeger & Eagan, 2010) and first-generation students are four times more likely to drop out than continuing generation students (Petty, 2014; Soria & Stebleton, 2012).

Being identified as low-SES has also been linked with higher dropout intention (Xu, 2015). Considering that students from low SES homes are less likely to pursue higher education (National Science Board, 2016), loss of this student group could result in a large net financial loss for institutions (Johnson, Van Ostern, & White, 2012). Further, students in lower socioeconomic classes have been shown to enter postsecondary education less academically prepared than students from higher economic levels (Alon, 2009; Klasik, 2011), and lack of

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academic preparation positively correlates with student attrition (Atherton, 2014). With underrepresented minority (URM) students making up a larger portion of PELL grant recipients (Crisp et al., 2009), it is no wonder higher education institutions struggle to close the achievement gap between URM and non-URM students (National Science Board, 2016).

Pre-college Variables

Insufficient pre-college academic preparation has been identified as one of the major barriers to college student retention. High school faculty often express difficulty in working with large classes of students with varied skill levels, frustration with the lack of preparation of students attending class, and negative consequences for higher-skilled students whose learning is stunted by instruction aimed to address the learning needs of lower-skilled students (Grabarnik & Yaskolko, 2015). Possibly connected to these inequities in students' high school experiences, Bound, Lovenheim, and Turner (2010) found newer cohorts of students entering postsecondary institutions to be less prepared than their predecessors. For example, a large percentage of students who enter college test into and subsequently enroll in remedial courses during their first term (Bahr, 2013). This pattern of remedial course-taking leads to a gap in time between students' entrance to college and their taking of actual college-level courses, which appears to influence student attrition rates (Bahr, 2011).

College Variables

Previous research has identified numerous college academic and social support variables that affect retention, including first-term coursework (e.g., Flanders, 2015; Kassaee & Rowell, 2016), and campus student support services (e.g., Lane, 2016; Reyes, 2011; Stanford et al., 2015). The coursework taken by

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students in their first term of college is an important predictor of retention (Flanders, 2015). Research has shown that students who enter college requiring remediation in below-college-level mathematics courses do not fare well academically, often dropping out of college within the first year (Bahr, 2011; Grabarnik & Yaskoko, 2015). Additionally, the number of times a student attempts a mathematics course has been correlated with both retention and graduation (Shaw & Barbuti, 2010).

Regarding campus support services, prior research has shown that academic advising and participation in a first-year experience course influence college student retention. Concerning advising, studies have shown that students participating in intrusive academic and social programs have higher retention rates and increased graduation rates (Dagley, Georgiopoulos, Reece, & Young, 2016; Stanford et al., 2015; Windsor et al., 2015). For example, in a large, multi-institution study, Bettinger and Baker (2013) found that students receiving prescriptive advising showed higher retention levels at 6 and 12 months than students not receiving prescriptive advising. Moreover, these gains were often higher for URM and female students (Dagley et al., 2016). Conversely, students have also self-reported greater intentions to drop out when they have felt insufficient access to faculty for support and advising (Xu, 2015).

In addition to academic advising, the literature concerning campus support services shows that a popular early intervention to address student retention is the implementation of first-year experience courses (Erickson & Stone, 2012). These courses often introduce students to a variety of other campus support services, teach key academic skills, and provide meaningful opportunities for peer-to-peer learning (Deschamp & Latulippe, 2013; Einfalt & Turley, 2013; Hammond, Bithell, Jones, & Bidgood, 2010). Student participation in a first-year experience

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course has been shown to increase GPA, overall term credits toward graduation, and retention (Ben-Avie et al., 2012). Additionally, students who participated in a first-year experience course have reported more engagement with their campus (Purdie & Rosser, 2011), which has in turn been correlated with student retention (Shook & Keup, 2012).

While first-year experience courses have been directly correlated with college student retention (Koenig, Schen, Edwards, & Bao, 2012), another prevalent intervention, the implementation of student learning communities, has been shown to have an indirect relationship with retention (Dagley et al., 2016). A learning community involves placing students into cohort groups and infuses curricular, and sometimes residential, components with campus engagement activities to increase student major retention (Dagley et al., 2016). Learning communities have been shown to increase student connections to the educational institution and their peers, facilitate an intellectual and emotional bond between students, and enhance students' perceptions of positive messaging around their academics and growth (Fink & Hummel, 2015). Such messaging may then influence student retention, as research has shown a significant correlation between student academic expectations and intentions to return to their postsecondary institutions (Erickson & Stone, 2012).

Retention for STEM Majors

Supplementing the research on general college student retention, work has been done to examine retention specifically for students majoring in STEM disciplines. The demographic, pre-college, and college variables that have been shown to influence STEM major retention will be discussed in the following paragraphs.

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Demographic Variables

Demographic variables studied in relation to STEM major retention include gender and race/ethnicity. Often, both female and URM students are targeted for first-year retention initiatives because they have been identified as having lower rates of STEM persistence than their male and non-URM counterparts (Griffith, 2010). But declaring and persisting in a STEM major is preceded by interest in STEM. As such, previous research has shown that differences exist between male and female interest in STEM disciplines. Researchers have found that the gender divergence in STEM begins in the teenage years (Gokhale, Rabe-Hemp, Woeste, & Machina, 2014; Peterson, Desy, & Brockman, 2011), with males showing more interest in STEM at an earlier point in their academic journeys and females developing more interest in STEM as they take more STEM courses (Gokhale et al., 2014). Gokhale et al. (2014) found that this difference in STEM interest continued until a student's senior year in college, when gender differences were no longer shown to exist between male and female interest in STEM.

Apart from interest in STEM disciplines, studies have shown conflicting results regarding the relationship between gender and retention in a STEM major. For instance, some prior research has shown that female students are less likely to declare a STEM major than male students (e.g., Rask, 2010). Griffith (2010), for example, found that one-half to one-third of female students declared a STEM major compared to male students. However, once female students have declared a STEM major, research has shown that they are more likely to remain in that major (Crisp et al., 2009; Griffith, 2010). Conversely, Chen and Soldner (2014) found that females who declared a STEM major at matriculation were less likely to earn a STEM degree than male STEM majors. The literature has suggested that these differences could be due to science attitude. Gokhale et al.'s (2014) study

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indicated that while females have a more positive outlook towards school and learning, male students are more motivated to succeed in science. Gokhale et al. (2014) further concluded that the longer female students remain in a STEM major, the higher their interest in STEM and the more likely they are to complete a degree.

Furthermore, additional work has shown that gender is a contributing factor to persistence specifically in an engineering major, with males having significantly higher rates of retention in that discipline (Meyers, Silliman, Gedde, & Ohland, 2010), while another study found that female students reported the gender composition of their major is a significant contributor to their retention in STEM majors (Griffith, 2010). However, Griffith (2010) also found that a gender gap does not exist in STEM major retention after controlling for academic preparation and other school experiences.

Regarding race/ethnicity, White students are the largest group to enter in and persist in STEM majors, though Asian students are more than twice as likely to obtain a STEM degree as other racial/ethnic groups (Kena et al., 2016; Maltese & Tai, 2011). Kokkelenberg and Sinha (2010) suggested that this difference is likely due to high school performance, with URM students averaging lower high school GPAs and mathematics placement scores.

Pre-college Variables

The pre-college variables cited in the literature on STEM major retention include students' high school GPA, rigorous course-taking and mathematics course-taking patterns in high school, and college entrance examination scores. For instance, students with higher high school GPAs (3.00 and above) earn more units counting toward a STEM degree within their first year in college than students with lower GPAs (lower than 2.50) (National Center for Education

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Statistics, 2015b). Additionally, research has shown that almost 50% of first-year STEM majors with high school GPAs below 2.50 dropped out of college (Chen & Soldner, 2014; Grabarnik & Yaskolko, 2015).

Rigorous course-taking in high school has also been found to influence college student retention in a STEM major. For example, completion of high school Advanced Placement (AP) course credits has been identified as a significant contributor to college STEM major persistence for both female and URM students (Griffith, 2010). Additionally, other literature has indicated that students who do not complete AP courses in high school have a higher likelihood of switching from STEM to non-STEM majors prior to college graduation (Shaw & Barbuti, 2010).

Apart from rigorous course-taking in general, high school mathematics course-taking, as well as success in mathematics courses, have been shown to be related to college student persistence in a STEM major. For instance, earning higher grades in high school mathematics courses has been correlated with both college retention and graduation in a STEM discipline (Maltese & Tai, 2011). In addition, prior research indicated that students who take lower-level mathematics courses in high school enter postsecondary education lacking the knowledge required to complete a college-level mathematics course (Moses et al., 2011), and other studies have found that, even without accounting for grades earned in mathematics courses, mathematics course-taking patterns in high school do influence STEM major persistence in college. For example, research has shown that students who take Algebra II, trigonometry, or calculus in high school are more likely to persist in a STEM major than students who take lower-level mathematics courses (Maltese & Tai, 2011). This finding was supported by a national study that identified students who took lower-level mathematics courses

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in high school (i.e., courses below Algebra II and trigonometry) as having an increased likelihood of changing from a STEM to a non-STEM major in college (Chen & Soldner, 2014).

Further, students who are considered "on track" to take higher-level mathematics courses in college often take Algebra I in the eighth grade, subsequently completing higher sequential mathematics courses throughout their K-12 careers to be prepared to take calculus upon their entry to college (Bressoud et al., 2015). This is important because calculus-readiness has been identified as a predictor of STEM major retention in the first college year (Moses et al., 2011). Nearly three-quarters of students who eventually take calculus, a gateway course in many STEM disciplines in college (Ellis, Fosdick, & Rasmussen, 2016), have already taken their first calculus course in high school (Bressoud et al., 2015). Yet of the students requiring mathematics remediation upon college entrance, more than 45% took pre-calculus or calculus in high school (Soldner, 2012). In addition, Chen and Ho (2014) reported that students who enter college as STEM majors but who completed less than Algebra II in high school earn significantly fewer STEM units during their first year of college.

Moreover, scores from the Scholastic Aptitude Test (SAT) and the American College Test (ACT) examinations, often taken by high school students to be used as part of their college admissions applications, are other predictors of retention in a STEM major. For example, Ost (2011) found that students with higher SAT scores tended to have increased tendencies to pursue a degree in the physical sciences (Ost, 2011). SAT mathematics scores have been cited as consistently predicting student persistence in a STEM major (Ost, 2011; Rask, 2010), with students who have a higher mean SAT mathematics score persisting in a science or mathematics discipline at higher rates than students with lower mean

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scores (Scott, Tolson, & Huang, 2009). In addition, ACT scores have been identified as positive predictors of major change for specific STEM majors (Leuwerke, Robbins, Sawyer, & Hovland, 2004; Nguyen et al., 2016).

College Variables

There exist bodies of work on both persistence in any college major and persistence specifically in a STEM major. While this section will focus primarily on the factors that influence persistence in STEM majors, it is worth noting some of the variables related to general major persistence. For instance, some of the barriers to major persistence investigated in prior research include financial pressure to pay for college, decreased satisfaction with the quality of academics provided, low cumulative GPA, weak commitment to degree completion, and limited social participation on college campuses (Xu, 2015). However, it has been found that significant positive predictors of major persistence include a combination of participation in curriculum on career planning, a student's declared major upon entry to college, a student's career interests (Belser, Prescod, Daire, Dagley, & Young, 2016), and a student's confidence in her or his major (Allen & Robbins, 2008).

College variables that have been specifically linked to STEM major retention and persistence include both academic and social factors, as well as personal feelings toward STEM disciplines. Academic factors that play a role in STEM retention include students' academic performance, credits taken, grades earned in mathematics courses, remedial course-taking, and participation in STEM-related programs or activities. Concerning academic performance, numerous studies have found GPA to influence students' decisions to persist in STEM majors (e.g., Allen & Robbins, 2008; Chen & Soldner, 2014; Crisp et al., 2009; Jaeger & Eagan, 2011; King, 2015; Maltese & Tai, 2011; Ost, 2011; Rask,

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2010; Shaw & Barbuti, 2010). Specifically, first-term GPA has been shown to predict STEM major retention (Allen & Robbins, 2008; Crisp et al., 2009; Gilmer, 2007; Jaeger & Eagan, 2011). Apart from GPA, students who performed well in their chemistry courses indicated less motivation for leaving their chosen STEM major (Perez, Cromley, & Kaplan, 2014), while earning lower grades in STEM courses has been shown to increase the probability of students switching to non-STEM majors (Chen & Soldner, 2014; Maltese & Tai, 2011; Ost, 2011; Rask, 2010). Similarly, students who completed less than 25% of their attempted STEM units have been shown to have a significantly higher probability of switching to a non-STEM major (Chen & Soldner, 2014), while those that do switch report a higher percentage of withdrawn or failed grades in STEM courses during their first year (Maltese & Tai, 2011).

Furthermore, studies have shown that students are more likely to switch from a STEM to a non-STEM major when they take mathematics courses that do not count toward their major (Honken & Ralston, 2013) or earn no mathematics credits within their first college year (Chen & Soldner, 2014), as happens when students take remedial mathematics courses in college. One study that exemplifies the relationship between retention in a STEM major and many of the factors outlined above was conducted by Alkhawawneh and Hargreaves (2014), who analyzed student characteristics, environmental influences, and academic support services and found that first-year college GPA, credits earned, and grade in first-term mathematics course grade all positively contributed to first-year retention for STEM majors.

Student participation in STEM-related programs or activities offered in college also influences persistence in a STEM major. For example, summer bridge programs and field trips integrated with local industry (Gilmer, 2007) have

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all been identified in the literature as positive contributors to STEM major retention, as well as having specific classroom discussions on major-specific topics related to things like workplace ethical and legal issues (Franchetti, 2011). Deschamp and Latulippe (2013) also found that STEM students reported that their participation in a first-year experience course in STEM contributed to their sense of improved science community, enhanced critical thinking, and a better understanding of STEM majors. Complimentarily, student participants in a study by Lane (2016) reported feeling better prepared, obtaining higher levels of self-confidence, and forming peer connections after participating in a first-year experience course. In addition, participation in a STEM learning community has been shown to significantly and positively contribute to retention for underclassmen and female and URM students (Dagley et al., 2016; Windsor et al., 2015). Similarly, Malm, Bryngfors, and Mörner, (2012) attributed supplemental instruction to a reduction in the attrition rates of STEM majors, who completed a greater number of credits than students who did not participate in supplemental instruction. Furthermore, Hardy and Aruguete (2013) found that higher rates of student absenteeism negatively impacted persistence in a STEM major. In addition to academic factors, social factors, including camaraderie with peers, professors, and advisors in the major have been identified as influencing STEM major retention (Morganson et al., 2015).

Concerning personal feelings toward STEM disciplines, Carlone and Johnson (2007) asserted that recognition by others as someone with talent and potential in science is a significant contributor to STEM success. Other research contends that science identity development is an integral factor in STEM retention (Lane, 2016), shaped by the way a student perceives his or her science learning environment (Carlone & Johnson, 2007). Exposure to role models has also been

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shown to increase the development of a science identity (Carlone & Johnson, 2007). Stronger levels of science identity have also been positively linked to student self-efficacy (Shin, Levy, & London, 2016) and greater retention in STEM majors (Perez et al., 2014).

Contributors to Mathematics Success for STEM Majors

Although mathematics serves as a foundational course for STEM disciplines (Bressoud et al., 2015), Chen and Ho (2014) reported that up to 40% of students seeking a bachelor's degree in STEM do not take a mathematics course in their first year of college. Completion of a college-level mathematics course within the first year of college has been identified as a contributor to STEM retention through graduation (Chen & Soldner, 2014) and is important to the completion of a STEM major in a timely fashion, as STEM prerequisites are often highly prescriptive in nature (Shaw & Barbuti, 2010). In addition, close to 50% of all students entering college require mathematics remediation, extending their time to graduation, and of these students, only 27% complete a bachelor's degree (Chen & Ho, 2014). Statistics such as these indicate that mathematics courses act as a gatekeeper to both general college student retention as well as retention in STEM majors. As such, the following section will describe the factors that contribute to mathematics success for STEM majors.

Demographic Variables

Prior research has found that gender, race/ethnicity, SES, and first-generation status all contribute to mathematics success for STEM majors. For example, national reports indicate that of the students who test into mathematics courses that are below college level, the majority are low-SES, URM students with

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parents who did not receive a high school diploma (Chen & Ho, 2014). Research has also shown that female, URM, and low-SES students consistently perform under par in higher-level mathematics courses (Bressoud et al., 2015). Race/ethnicity has also been shown to be a factor in mathematics success for STEM majors, as more than 65% of students in calculus courses at a four-year college or university intend to complete a STEM degree, though these courses are filled with White, male students (Bressoud et al., 2015). Consequently, institutions of higher education may likely lose a large portion of their female and URM students from STEM majors by the time calculus is due to be taken in their degree pathway.

Pre-college Variables

Previous research has identified high school mathematics instruction and performance on the SAT exam as influencing college-level mathematics course success. For example, a study by Wade, Sonnert, Sadler, and Hazari (2017) study was partly driven by the researchers' identification of challenges in student transition between secondary and postsecondary mathematics courses. These scholars suggested that one likely reason students exhibit poor mathematics course performance in college is the difference between high school mathematics preparation compared to college mathematics course expectations. The study findings indicated that a student's ability to define and construct high school mathematic concepts positively predicted a student's performance in a college calculus course.

Similarly, a study by Moses et al. (2011) suggested that students who take lower-level mathematics courses in high school enter postsecondary education lacking the knowledge required to successfully complete a college-level mathematics course. The researchers found that this is likely due to a student not

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having completed college preparatory coursework in high school and not knowing what is expected of them in college courses. This knowledge gap then leads to students' frustration with their lack of academic achievement and possibly contributes to STEM attrition.

Additionally, a study by Dagley et al. (2016) found that students scoring in the second and third quartiles on the mathematics section of the SAT exam had higher college STEM student attrition rates than STEM students with higher mathematics SAT scores. This study analyzed an intervention program for students scoring below the first tier on the mathematics section of the SAT exam and they discovered that the differences between students persisting and not persisting in STEM majors were likely due to low performance in students' mathematics courses.

College Variables

Regarding college variables, prior research has examined the roles of remedial course-taking in mathematics, pass rates in mathematics courses, participation in STEM-related programs or activities on mathematics success for STEM majors, and the use of technology in mathematics courses. Regarding the influence of remedial course-taking in mathematics, Bahr (2013) found that as a student takes lower levels of remedial mathematics courses, the likelihood of the student successfully completing a mathematics course decreases and the likelihood that the student will drop out of college increases. Additionally, Grabarnik and Yaskolko (2015) found that, when given the choice of taking a remedial course sequence prior to taking college-level mathematics, students who opted to bypass the remedial courses had significantly lower rates of STEM major retention. Concerning pass rates in mathematics courses, Bahr (2011) found that passing a mathematics course on the first attempt was correlated with passing all subsequent

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mathematics courses in the sequence. Conversely, Bahr's (2011) study found that not passing a mathematics course on the first attempt strongly correlated with students dropping out of the mathematics sequence altogether.

Literature on STEM-related programs or activities offered on some college campuses that contribute to student success in mathematics includes research on intensive summer mathematics programs and tutoring. For instance, Kassaee and Rowell (2016) conducted a study where incoming college freshman, among them STEM majors, were required to participate in a 2-week summer bridge program consisting of an intensive mathematics courses prior to their first term of enrollment. Afterward, these same students received specialized mathematics tutoring and academic advising throughout their first year in college. Results of this study showed that pre-calculus test scores improved following the interventions, with female students making greater gains than male students. In addition, 81% of the students who participated in the intervention earned a passing grade in a pre-calculus course as opposed to only 73% of students who did not participate in the intervention (Kassaee & Rowell, 2016).

Additionally, Thompson and McCann (2010) found that students experienced success in lower-level college mathematics courses when a technology-based component was implemented. The technology-based model in their study reduced in-class meetings and replaced them with online learning activities. Their findings indicated that infusing technology-based mathematics instruction into coursework not only improved success in the mathematics course but reduced student mathematics anxiety.

Theoretical Framework

The theoretical model, achievement goal theory, utilized in this study was developed based on the research summarized in this chapter and includes factors

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contributing to college student retention in STEM majors to the sixth college term. In this current study, it was hypothesized that demographic variables, pre-college variables, and college variables influence college student retention in STEM majors. The demographic variables examined included gender, race/ethnicity, and SES. The pre-college variables analyzed include high school GPA and the determinants in high school that regulated student placement in a mathematics course in college. Finally, the college variable examined was if a student passed a college-level mathematics course during his or her first term in college. While not all the variables that existing research has previously shown to contribute to STEM major retention are included in the model used in this study, all the variables to which the researcher had access were included.

Limitations of Existing Research on STEM Major Retention

This study fills a gap in the literature by investigating the role first-term mathematics course-taking, mathematics course placement, and first-term mathematics course grade has on college student retention in STEM majors. To date, there are no studies analyzing whether passing a first-term college-level mathematics course below Calculus I increases the likelihood of STEM major retention through a student's sixth college term. Additionally, the literature is absent of studies examining the role of college mathematics placement, outside of AP exam placement, on STEM major retention through the sixth college term.

Summary

This chapter reviewed the literature to date on general college student retention, factors associated with retention specifically for STEM majors, and contributors to success in mathematics for STEM majors, including the

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demographic, pre-college, and college variables in each of these areas. The chapter concluded with a description of the theoretical framework on which the study was built, as well as a discussion on the limitations of the existing research on retention in STEM majors. Chapter 3 will detail the research methodology utilized in conducting the present study.

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CHAPTER 3: METHODOLOGY

This chapter discusses the research design of the study. The following sections detail the research questions, data collection procedures, study participants, predictor and outcome variables, methods of data analyses, and methodological limitations of the study.

Research Questions

The current study investigated the following research questions:

1. Are there differences between the characteristics of college students who do and do not persist in STEM majors to the sixth college term?
2. What is the contribution of demographic variables, pre-college variables, and college variables to persistence in STEM majors to the sixth college term?

Research Design

Logistic regression was used to analyze the relationships between demographic, pre-college, and college variables and the likelihood that students were retained within a STEM major by the end of their sixth college term. The study used unobserved latent traits and abilities as measurements for statistical analysis, which is the foundation of quantitative methodological research (Wilson & Gochyyev, 2013). It was determined that the quantitative method was most appropriate for this study as the variables being analyzed came from archival numerical data, the use of which was necessary to statistically analyze predictors of STEM major retention.

Data Collection

Data for this study were collected from archival records provided by the university under study. Data came from student records in the form of aggregated

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output from multiple university databases, including students' university applications, registration and enrollment records, and financial aid records. The data set included non-personally identifiable information pertaining to first-time freshmen students who declared STEM majors at matriculation and who enrolled between the Fall 2008 and Fall 2013 terms. The information gleaned from the records included participants' race/ethnicity, gender, expected financial contribution from family, high school GPA, determination of college mathematics course placement, students' major and concentration at matriculation, first-term college mathematics course taken, first-term college mathematics course grade, and students' major and concentration at the end of the students' sixth college term.

Participants

The site of the study was a 4-year, public university in California. The institution is a designated Hispanic Serving Institution (HSI) and enrolls approximately 9,500 undergraduate, graduate, and doctoral students. The institution serves students from the following demographic groups: 60% female, 55% Hispanic/Latino, 18% White (non-Hispanic), 7% Asian, 6% Black, 3% two or more races, and 1% or less each of American Indian/Alaska Native and Pacific Islander students.

Participants consisted of all first-time freshmen who enrolled in the university between the Fall 2008 and Fall 2013 terms, (n = 700). Post-baccalaureate students and returning freshmen were excluded from the study. At the time of matriculation, all the participants met college-ready mathematics requirements during their first college term. In addition, they declared and were enrolled in an undergraduate STEM major (i.e., biology, human biology, biochemistry, computer science, geology, mathematics, natural sciences, or

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physics). The university under study also offers three relatively new engineering majors, but those majors have been excluded from this research due to the limited amount of student data available for them. Data were analyzed for all participants who had no missing data and who were enrolled in the university as STEM majors during the timeframe specified above (n = 625). The number of participants was found to be acceptable for statistical analyses based on exceeding the 20:1 events per variable ratio often used to determine sample size stability in logistic regression models (Van der Ploeg, Austin, & Steyerberg, 2014).

Descriptive statistics were computed to compare the characteristics of students retained in a STEM major through their sixth college term versus students who were not retained in a STEM major through their sixth college term.

Predictor Variables

This section discusses the following predictor variables: demographic, pre-college, and college variables, each of which will be discussed below.

Demographic Variables

Three demographic variables were included in the model, including students' gender, race/ethnicity, and SES. Gender and race/ethnicity were collected from the university admission application, and SES was determined through a student's eligibility for financial aid, as collected through the financial aid application. Race/ethnicity was self-reported as a student belonging to one or more of the following groups: (1) American Indian or Alaska Native, (2) Asian, (3) Black or African American, (4) Native Hawaiian or other Pacific Islander, (5) White, or (6) two or more races. In addition, students were given the option to decline to state their race/ethnicity. Gender was also self-reported, with a student's legally assigned sex as male and female being the only available options.

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Additional gender identification (e.g., non-binary, gender non-conforming) was optional for students to self-report and is not included in the dataset due to low reported numbers.

SES can be self-reported on the student's admissions application but is not a required field and often is not completed. For this reason, the federally reported Expected Family Contribution (EFC), collected by the university's financial aid department, as an indicator of SES. As EFC differs from year-to-year, the researcher recoded EFC each year to determine whether a student was low-SES.

Pre-college Variables

Two pre-college variables, high school GPA and the determinants in high school that regulated student placement in a mathematics course in college, were used in this study. High school GPA was collected from an official high school transcript that was submitted to the university when the student applied for university admission. Cumulative high school GPA, based on a 4.00 scale, was rounded to the nearest hundredth. Placement into a first-term college-level mathematics course was determined by a student's completion of one of the following :

a) a score on the Entry Level Mathematics (ELM) placement exam that placed the student in a college-level mathematics course,
b) a qualifying score on the ACT exam,
c) a qualifying score on the mathematics portion of the SAT I exam,
d) a qualifying score on the SAT mathematics (SAT-M) subject exam,
e) a qualifying score on the AP exam for Calculus AB or Calculus BC,
f) passing one remedial mathematics course in a summer bridge program at the university of study,

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g) passing two remedial mathematics courses in a summer bridge program at the university of study,

h) completing a university-sponsored summer course to fulfill the remedial mathematics requirement prior to the start of the first college term,

i) completing a high school early assessment program and passing 4 years of high school mathematics courses, including one college-level mathematics course, or

j) placement into a college-level mathematics course not otherwise specified.

Students with an ELM score below 50, non-exempt students, who have not placed in college-level mathematics through a conditional method are required to complete remedial coursework during the summer prior to first-term enrollment in the fall. Students who did not complete the summer remedial coursework and continued in remedial coursework in the fall of their first term were excluded from the study.

College Variables

One college variable, students who passed a first-term college-level mathematics course versus students who did not take or did not pass a first-term college-level mathematics course, was used in this study. The variable was created by combining the college-level course a student took during their first-college term and subsequent grade earned. Students that did not take a mathematics course their first-college term were included with students who did not pass their first-term college-level mathematics course. Table 1 presents the description of logistic specifications.

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Table 1

Description of Logistic Specifications

Variables	Coding
Demographic Variables	
Gender	Sex Male = M, Female = F
Socioeconomic status	Low socioeconomic status = Y Not low socioeconomic status = N
Ethnicity	Non-URM students (White, Asian) = 1 URM students = 0
Pre-College Variables	
High school GPA	GPA 3.00 or higher = 1 GPA 2.999 or lower = 0
Mathematics placement at the college-level determined by one of the following criteria:	Earned high score on SAT exam = Exempt (SAT I)
	Earned a high score on SAT-Math subject exam = Exempt (SAT Subject Test-Math)
	Earned a high score on ACT exam = Exempt (ACT I)
	Earned a passing score of 3 or higher on the AP Calculus exam= Exempt (College Board)
	Earned a qualifying score on the university Entry Level Math (ELM) exam = Qualified ELM 550+
	Passed one remedial mathematics course during a summer bridge program at the institution under study = Not Qualified (1 remedial)
	Passed a remedial mathematics requirement through a summer bridge program outside the institution of study = Exempt ESM
	Passed two remedial mathematics courses during a summer bridge program at the institution under study = Not Qualified (2 remedial)
	Tested into a remedial mathematics course and completed a university sponsored summer course to fulfill the requirement prior to the start of the first college term = Qualified (Completed Rem)
	Completed a high school early assessment program and passed four years of high school mathematics courses, including one college-level mathematics course = Exempt Per Ear Asmnt Prog
	Completed placement requirements not otherwise specified = Not Exempt
College Variables	
First-term college-level mathematics course	Passed first-term college-level mathematics course = 1
	Did not pass first-term college-level mathematics course -or- did not take a first-term college-level mathematics course = 0
Outcome Variable	
STEM major retention at the sixth term	Not Retained = 0
	*Retained = 1

Note. *Reference category

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Outcome Variable

The outcome examined in this study was student retention in a STEM major at the sixth college term. Retention in a STEM major was determined by an individual student's major group at matriculation and then again at the sixth college term. The choice to study STEM major persistence through the sixth college term was made because most universities require students to declare a major by the end of the spring term prior to their junior year (Griffith, 2010). This timeframe allows institutions to understand the role a first-term college-level mathematics course has on students maintaining their focus on STEM through major declaration or to change to a major outside of a STEM discipline. In addition, previous researchers have studied STEM major persistence through the end of students' sophomore year in college (Allen & Robbins, 2008; Griffith, 2010; Harackiewicz et al., 2002).

A major at matriculation refers to the major a student declared when she or he registered for classes during the first college term. For this study, the student's major at matriculation was used as the baseline major on which retention in a major was determined. Majors included in this study were biology, human biology, biochemistry, chemistry, computer science, geology, mathematics, natural sciences, and physics.

With the guidance of an academic advisor, students with declared STEM majors were enrolled in one of several mathematics courses (e.g. elementary statistics, Pre-calculus IA, Pre-calculus IB, Pre-calculus II, Calculus I, II, or III) during their first college term. For the purposes of this study, the mathematics courses were divided into two groups. Group A included mathematics courses requiring trigonometry-based Calculus I and/or higher-level mathematics courses and Group B included mathematics courses that did not require trigonometry-

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based Calculus 1 or Elementary Statistics (Group B). Table 2 displays the majors assigned to either Group A or Group B.

Table 2

Major Group Dependent on Mathematics Requirement

Major Group A	Major Group B
Biology-Biotechnology	Biology-Traditional
Chemistry	Human Biology
Biochemistry	Natural Sciences
Computer Science	Computer Science – Information Systems
Geology B.S.	Geology B.A.
Mathematics	
Physics	

Students were classified as *retained* if their major group at the sixth college term was within the same group of STEM majors (Group A or Group B) as their major group at matriculation. Students were classified as *not retained* if their major group at the sixth college term was different from their major group at matriculation but still within a STEM discipline that required a lower level mathematics course, if their major was outside of a STEM discipline, or if they were no longer enrolled in the university. Students who switched to a STEM discipline with a lower-level mathematics requirement (e.g., Precalculus I or II, Elementary Statistics I) were grouped with students that switched to a non-STEM major and students no longer enrolled in the university. These groups were formed to gain a more thorough understanding of how passing a first-term college-level mathematics course effects STEM majors switching between disciplines with different mathematics course requirements. Students enrolled as an undeclared major at matriculation were excluded from the sample.

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Data Analyses

Data analyses were conducted using SAS University Edition software (Introduction to SAS, n.d.). SAS was chosen for use in this study because it allowed for modification of the syntax to analyze variable interaction. SAS is only able to process cases with full data sets and automatically excludes missing cases from the overall sample (Introduction to SAS, n.d.).

The final logistic regression model was determined by utilizing backwards model selection. The model was fit with all the variables. The binary variable interactions were analyzed and the least significant variable pair was removed. The model was refit with the remaining variables. These steps were repeated until only singular variables without significant interaction remained. The final model used the Wald chi-square statistic and p-values to determine model fit statistical significance (Hosmer et al., 2013). The p-value of, $P < .05$, was used to determine whether the predictor variables were significantly related to the dependent variable. Use of the p-value in this manner is an accepted method of determining significance in logistic regression (Hosmer et al., 2013).

The odds ratio variable was used to interpret the effect size of the predictor variables in the logistic regression model. SAS exhibits the odds ratio coded as $\exp\beta$ in its statistical output (Introduction to SAS, n.d.). The odds ratio statistic is an acceptable interpretation of effect size in logistic regression models if the predictor variables are binary (Grace-Martin, n.d.). Additionally, a parameter estimate was run to determine whether the study sample means were indicative of the entire population (Hosmer et al., 2013).

Descriptive Statistics

To answer the first research question, descriptive statistics were computed to explore and compare the characteristics of students who were retained in a

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STEM major through the sixth term in college with those students who were not retained in a STEM major through their sixth term in college. Frequencies were computed to determine the percentages.

Logistic Regression

To answer the second research question, a regression model was used to examine the relationship between the dichotomous (*retained* vs. *not retained)* dependent variable and the set of predictor variables. Logistic regression was chosen as the method of data analysis because the study involved a dichotomous dependent variable and multiple independent variables (Hosmer et al., 2013). Retention in a STEM major to the sixth college term was coded as the reference category.

Assumptions

A logistic regression model has several assumptions, including that the relationship between the predictor and dependent variables is linear and the predictor variables are not closely related (multicollinear) (French, Immekus, & Yen, 2013). To test for collinearity of variables, an estimated standard of error analysis was performed.

The characteristics of the study participants (labeled as the $_{i}$th student) consisted of the following predictor variables: (a) demographic variables (i.e, race/ethnicity ($Ethnicity_i$), gender (Sex_i), socioeconomic status ($LowSES_{\mathrm{i}}$)), (b) pre-college variables (i.e., high school GPA (GPA_i), college mathematics placement ($MthPlmt_i$), and (c) college variables (i.e., mathematics course taken during the first term of college ($Catalog_i$), grade obtained in first-term college mathematics course ($Grade_i$).

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To explore if the effect of one predictor variable was dependent on the value of another predictor variable, interactions were considered in the logistic regression model. The syntax in the statistical software was modified so that each predictor variable, except mathematics placement, was categorical and binary. Mathematics placement was categorical but had 11 response levels to allow the researcher to identify possible differences in how students placed into a first-term college-level mathematics course and STEM major retention through the sixth college term.

The binary variable for gender included male and female. The final variable was coded Sex_i. The binary variable for race/ethnicity included URM students (Hispanic, Black, American Indian, Pacific Islander) and non-URM students (White, Asian). The final variable was coded as $Ethnic_i$, (0, 1). The binary variable for socioeconomic status included students determined to be low socioeconomic status and students determined not to be low socioeconomic status. The final variable was coded Low_SES_i. The binary variable for GPA included students earning a high school GPA of 2.99 or lower and students earning a high school GPA of 3.00 or higher. The final variable was coded as $GPA1_i$ (0, 1). Mathematics placement was not coded as a binary variable due to the number of a ways a student is able to place into a college-level mathematics course. The final single variable was coded as $MthPlmt_i$. The two college variables titled first-term college-level mathematics course taken and grade received in that course were combined to make a binary variable that included (1) students who did not take a first-term college-level mathematics course or students who took but did not pass a first-term college-level mathematics course, and (2) students who passed a college-level mathematics course during their first term of college. The final variable was coded as $MCourse_i$ (0, 1). Table 3 visualizes the predictor variable coding.

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Table 3

Description of Predictor Variable Coding

Coding	Variable Description
Demographic Variables	
Sex$_i$	Sex Male = M, Female = F
Low_SES$_i$	Low socioeconomic status = Y Not low socioeconomic status = N
Ethnic$_i$	Non-URM students (White, Asian) = 1 URM students (Hispanic, Black, American Indian, Pacific Islander) = 0
Pre-College Variables	
HSGPA$_i$	GPA 3.00 or higher = 1 GPA 2.999 or lower = 0
MthPlmt$_i$	Earned high score on SAT exam = Exempt (SAT I)
	Earned a high score on SAT-Math subject exam = Exempt (SAT Subject Test-Math)
	Earned a high score on ACT exam = Exempt (ACT I)
	Earned a passing score of 3 or higher on the AP Calculus exam= Exempt (College Board)
	Earned a qualifying score on the university Entry Level Math (ELM) exam = Qualified ELM 550+
	Passed one remedial mathematics course during a summer bridge program at the institution under study = Not Qualified (1 remedial)
	Passed a remedial mathematics requirement through a summer bridge program outside the institution of study = Exempt ESM
	Passed two remedial mathematics courses during a summer bridge program at the institution under study = Not Qualified (2 remedial)
	Tested into a remedial mathematics course and completed a university sponsored summer course to fulfill the requirement prior to the start of the first college term = Qualified (Completed Rem)
	Completed a high school early assessment program and passed four years of high school mathematics courses, including one college-level mathematics course = Exempt Per Ear Asmnt Prog
	Completed placement requirements not otherwise specified = Not Exempt
College Variables	
MCourse$_i$	Passed first-term college-level mathematics course = 1
	Did not pass first-term college-level mathematics course -or- did not take a first-term college-level mathematics course = 0

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The form of the final model suggested with backwards model selection, the probability of a student being retained at the sixth college term, denoted as *p*, is

$$\ln[p(x)/1-p(x)] = \beta_0 + \beta_1\,(Ethnic_i) + \beta_2\,(Sex_i) + \beta_3\,(Low\_SES_i)$$
$$+\ \beta_4\,(MCourse_i) + \beta_5\,(GPA1_i) + \beta_6\,(MthPlmt_i)$$

A second backwards model selection analysis was then run to with all calculus courses removed from the data. The backwards model selection determined that logistic regression was an appropriate model. This was performed to determine whether the higher-level mathematics course data deletion yielded any difference in significance between the predictor and dependent variables. Table 4 presents the research questions, predictor variables, and method of analysis for each research question.

Table 4

Research Questions, Predictor Variables, and Method of Analysis

Research Question	Predictor Variables	Method of Analysis
Research Question 1: Are there differences between the characteristics of college students who do and do not persist in STEM majors to the sixth college term?		Frequencies
Research Question 2: What is the contribution of demographic variables, pre-college variables, and college variables to persistence in STEM majors to the sixth college term?	High school GPA Mathematics course placement in the first college term Mathematics course passed, not passed, or not attempted during the first college term	Logistic regression

Limitations

The study contains certain limitations. One limitation is that the research design included a data set obtained from one institution. While this is common in research studies on higher education (e.g., Flanders, 2015; Kassaee & Rowell, 2016; Nguyen et al., 2016; Xu, 2015), other literature has suggested that limiting

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data to one institution could be a limiting factor because it excludes external validity, is not generalizable, and the environments are often not controlled enough to obtain internal validity (Schanzenbach, 2012). Another limitation of the current study is that it is possible that college students could change their majors from matriculation to the sixth college term without changing their declaration in the university system. This limitation could impact the percentage of students listed as retained who may not have been retained. Furthermore, this research omitted additional pre-college and college variables previously found in the literature to be predictors of student retention in STEM majors (e.g., last mathematics course taken in high school, delimitation between students who dropped out of college versus students who changed from STEM to non-STEM majors) that could have yielded additional results. These variables were not included in the present study because the university that served as the site of this research could not provide them.

Moreover, the current study focused solely on student persistence in a STEM major group rather than on persistence in individual STEM majors. Thus, the study did not examine students who persisted in the same individual STEM majors that they declared at matriculation and the factors that may affect their decisions to do so. Lastly, this study investigated persistence in a STEM major only through the sixth college term but did not look at retention in a STEM major through college graduation. Doing so does not account for students who change their majors later in their college careers.

Summary

This chapter outlined the research design of the study, including the research questions, data collection procedures, study participants, predictor and

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outcome variables, methods of data analyses, and methodological limitations of the study. The following chapter will discuss the results of the research study.

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CHAPTER 4: RESULTS

This chapter discusses the results of the research study. The first section describes the characteristics of the sample under study, followed by the findings for each of the research questions. Tables presenting the statistical results are also displayed.

Sample Characteristics

The dataset in this research was made up of 47% female and 53% male students with a declared STEM major at matriculation. A large portion (65%) of the sample was classified as low-SES, and 73% of the participants were URM students. Additionally, 63% of the sample entered college with a high school GPA of 3.00 or higher while 37% enrolled with a high school GPA of 2.99 or lower. Once enrolled, 37% of the students from the sample did not take or did not pass a first-term college-level mathematics course, while the remaining 63% passed a college-level mathematics course. Table 5 displays the characteristics of the study participants.

Findings for Research Question 1

The following section will discuss the findings related to Research Question 1: Are there differences between the characteristics of college students who do and do not persist in STEM majors to the sixth college term?

A descriptive comparison of students retained in a STEM major through their sixth college term (*n*=231) versus students who were not retained in a STEM major through their sixth college term (*n*=394) revealed numerous differences. Male students were retained at a higher rate than female students (75% males versus 66% females). Non-URM students far outnumbered URM students as retained in a STEM major through their sixth college term (73% versus 68%) and

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Table 5

Characteristics of Study Participants

Variable	Sample Characteristics (n = 625)	
	N	%
Demographic Variables		
Gender		
Male	331	53%
Female	294	47%
Ethnicity		
Non-URM students	169	27%
URM students	456	73%
Socioeconomic status (SES)		
Low SES	406	65%
Not low SES	219	35%
Pre-College Variables		
High school GPA		
GPA 3.00 or higher	456	73%
GPA 2.99 or lower	169	37%
Mathematics placement at the college-level determined by one of the following criteria:		
Earned high score on SAT exam	79	12.6%
Earned high score on SAT-Math subject exam	3	0.5%
Earned a high score on ACT exam	21	3.3%
Earned a passing score of 3 or higher on the AP Calculus exam	12	1.86%
Passed a remedial mathematics requirement through a summer bridge program outside the institution of study	45	7.2%
Earned a qualifying score on the university Entry Level Math (ELM) exam	113	18%
Passed one remedial mathematics course during a summer bridge program at the institution under study	116	18.7%
Passed two remedial mathematics courses during a summer bridge program at the institution under study	74	11.8%
Tested into a remedial mathematics course and completed a university sponsored summer course to fulfill the requirement prior to the start of the first college term	45	7.2%
Completed a high school early assessment program and passed four years of high school mathematics courses, including one college-level mathematics course	82	13.2%
Completed placement requirements not otherwise specified	35	5.6%
College Variables		
First-term college-level mathematics course		
Passed	394	63%
Did not pass or take	231	37%

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students classified as low-SES were retained in a STEM major through the sixth college term at a higher rate than students not classified as low-SES (73% versus 69%).

Students entering college with a high school GPA of 3.00 or higher outnumbered students entering college with a high school GPA of 2.99 or lower in being retained in a STEM major through their sixth college term (61% versus 54%). Also, students who passed a first-term college-level mathematics course were retained in a STEM major at a much higher rate than students who did not take or pass a first-term college-level mathematics course (75% versus 67%).

Concerning mathematics course placement in the first college term, students who placed into a first-term college level mathematics course by earning a high score on the SAT or ACT exam, earned a passing score of 3 or higher on the AP calculus exam, or passed two remedial mathematics courses during a summer bridge program showed higher rates of retention in a STEM major through the sixth college term when compared to the other means in which a student could place. The variable parameters obtained from the dataset motivate the use of these same variables in answering research question two. Table 6 contains a descriptive comparison of students who were retained in a STEM major at the sixth college term and students who were not retained in a STEM major at the sixth college term.

Findings for Research Question 2

The following section will discuss the findings related to Research Question 2: What is the contribution of demographic variables, pre-college variables, and college variables to persistence in STEM majors to the sixth college term?

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Table 6

Descriptive Comparison of Study Participants

Variable	Retained in STEM major at fourth term (n = 231)	Not-retained in STEM major at fourth term (n = 394)
Demographic Variables		
Gender		
M	75%	25%
F	66%	34%
Ethnicity		
Non-URM students	73%	27%
URM students	68%	32%
Socioeconomic status (SES)		
Low SES	69%	31%
Not low SES	73%	27%
Pre-College Variables		
High school GPA		
GPA 3.00 or higher	61%	39%
GPA 2.99 or lower	54%	46%
Mathematics placement at the college-level determined by one of the following criteria:		
Earned high score on SAT exam	86%	24%
Earned high score on SAT-Math subject exam	0%	100%
Earned a high score on ACT exam	75%	25%
Earned a passing score of 3 or higher on the AP Calculus exam	82%	28%
Passed a remedial mathematics requirement through a summer bridge program outside the institution of study	67%	33%
Earned a qualifying score on the university Entry Level Math (ELM) exam	68%	32%
Passed one remedial mathematics course during a summer bridge program at the institution under study	58%	42%
Passed two remedial mathematics courses during a summer bridge program at the institution under study	86%	14%
Tested into a remedial mathematics course and completed a university sponsored summer course to fulfill the requirement prior to the start of the first college term	49%	51%
Completed a high school early assessment program and passed four years of high school mathematics courses, including one college-level mathematics course	71%	39%
Completed placement requirements not otherwise specified	75%	25%
College Variables		
First-term college-level mathematics course		
Passed	75%	25%
Did not pass or take	67%	23%

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Backwards model selection was performed to determine the best model fit with utilizing the Chi-square test statistic and its corresponding p-value indicating significance at 0.05. The first logistic regression model considering all variables (e.g. gender, SES, ethnicity, HS GPA, mathematics placement, first-term college-level mathematics course) and two-way interactions between the binary variables (gender, SES, ethnicity, HS GPA, first-term college-level mathematics course). The least significant variable was removed from the model, the model refit, and logistic regression rerun. This method was repeated, removing the least significant variable one-by-one, until only significant variables remained. Table 7 visualizes the order in which the least significant variable pairs were removed to determine the best model fit.

Table 7

Logistic Regression Backwards Model Fit

Least Significant Variable Order of Removal	P-value
All Variables Run	
Mathematics course placement	0.990
SES*First-term college-level mathematics course	0.959
SES*Ethnicity	0.834
SES*Gender	0.778
Ethnicity	0.650
SES	0.635
HS GPA*First-term college-level mathematics course	0.613
Gender	0.504
First-term college-level mathematics*Ethnicity	0.382
First-term college-level mathematics*Gender	0.385
HS GPA*SES	0.283
HS GPA*Gender	0.320
HS GPA*Ethnicity	0.214
Gender*Ethnicity	0.125

Note: Significance determined using p-value < .05

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The final model using backwards model selection indicated that of the six predictor variables and 10 two-way interactions, only two had a statistically significant effect on the prediction of retention in a STEM major through the sixth college term. These two variables (i.e., students who entered college with a high school GPA of 3.00 or higher, students who took and passed a college-level mathematics course their first term in college) both have p-values below 0.05. The overall fit of the model was found to be significant with a Wald chi-square statistic of p value of < 0.05. The interactions between variables indicated no statistically significant effect on long-term STEM retention.

While the p-value of $< .05$ indicated that the predictor variables had an effect on retention in a STEM major through the sixth college term, it did not indicate the size of the effect (Sullivan & Feinn, 2012). Effect size has been a required component of reporting statistical significance since 2001 (American Psychological Association, 2010). However, it has become an accepted method to use odds ratios as the effect size if the variables are dichotomous (Haddock, Rindskopf, Shadish, & Appelbaum, 1998). The research design of this study modified all single variables, except mathematics placement, to be dichotomous. For this reason, the odds ratio was used as the effect size. For mathematics placement, which was not a dichotomous variable, an additional odds ratio estimate was performed if the p-value indicated significance.

An interpretation of the significant predictor variables indicated that students who entered college with a high school GPA of 3.00 or higher increased their odds of STEM retention through the sixth college term by a factor of 1.3. Further, the confidence intervals suggest that there is 95% certainty that the odds of STEM retention through the sixth college term for these students increased between a factor of 1.058 and 2.38. Additionally, students that took and passed a

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first-term college-level mathematics course increased their odds of long-term STEM retention by a factor of 1.3. The confidence intervals suggest that there is 95% certainty that the odds of STEM retention through the sixth college term for these students increased between a factor of 1.12 and 2.23. A two-way interaction was performed between the two statistically significant variables with results indicating a non-significant p-value. Table 8 displays the estimated regression coefficients, standard errors, odds ratios, and it's 95% confidence intervals for the final logistic regression model.

Table 8

Logistic Regression Model: Analysis of Maximum Likelihood Estimates

Variable	β	Standard Error	Odds Ratio[1]	95% Confidence Intervals	
Pre-College Variables					
High school GPA					
GPA 3.00 or higher	0.235	0.112	1.265*	1.058	2.38
College Variables					
First-term college-level mathematics course					
Passed	0.271	0.1069	1.311*	1.12	2.23

Note. *p < .05; [1] Only odds ratios with significant p-value are displayed

Findings for Research Question 2 Using Data Disregarding Calculus

To determine whether students who entered their first term of college and took a calculus course affected the probability of retention, logistic regression analyses were performed on a second dataset in which all calculus courses were removed, leaving only lower-level college-level mathematics courses while all other predictor variables remained the same.

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Backwards model selection was performed to determine the best model fit using the Chi-square test statistic and its corresponding p-value indicating significance at 0.05. The first logistic regression analysis considering all variables (e.g. gender, SES, ethnicity, HS GPA, mathematics placement, first-term college-level mathematics course) and two-way interactions between the binary variables (gender, SES, ethnicity, HS GPA, first-term college-level mathematics course). The least significant variable was removed from the model, the model refit, and logistic regression rerun. This method was repeated, removing the least significant variable pair one-by-one, until only significant variables remained. Table 9 visualizes the order in which the least significant variable pairs were removed to determine the best model fit.

Table 9

Logistic Regression Backwards Model Fit without Calculus

Least Significant Variable Pair	P-value
All Variables Run	
Mathematics course placement	0.990
SES*First-term college-level mathematics course	0.959
SES*Ethnicity	0.834
SES*Gender	0.778
Ethnicity	0.650
SES	0.635
HS GPA*First-term college-level mathematics course	0.613
Gender	0.504
First-term college-level mathematics*Ethnicity	0.382
First-term college-level mathematics*Gender	0.385
HS GPA*SES	0.283
HS GPA*Gender	0.320
HS GPA*Ethnicity	0.214
Gender*Ethnicity	0.125

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As with the primary logistic regression model results, the final model using backwards selection indicated that of the six predictor variables and 10 two-way interactions, only two showed a statistically significant effect on the prediction of STEM retention through the sixth college term. The two predictor variables (i.e., students who entered college with a high school GPA 3.00 or higher, students who took and passed a college level mathematics course during their first term in college) both have p-values below 0.05. The overall fit of the model was found to be significant with a Wald chi-square statistic of $p < .05$. Analysis of the variable interactions indicated no statistically significant effect on long-term STEM retention.

Moreover, a review of the results indicated that students with a high school GPA of 3.00 or higher who entered college eligible to take a college-level mathematics course below calculus increased their odds of retention in a STEM major through the sixth term by a factor of 1.21. Further, the confidence intervals suggest that there is 95% certainty that the odds of STEM retention through the sixth college term for these students increased between a factor of 1.042 and 2.365. Additionally, these students increased their odds of retention in a STEM major through the sixth term by a factor of 1.28 when they took and passed a first-term college-level mathematics course. The confidence intervals suggest that there is 95% certainty that the odds of STEM retention through the sixth college term for these students increased between a factor of 1.055 and 2.156. Table 10 displays the output including regression coefficients, standard errors, significance values, odds ratios, and model fit statistics.

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Table 10

Logistic Regression Model: Analysis of Maximum Likelihood Estimates without Calculus

Variable	β	Standard Error	Odds Ratio[1]	95% Confidence Intervals	
Pre-College Variables					
High school GPA					
GPA 3.00 or higher	0.232	0.108	1.207*	1.042	2.365
GPA 2.99 or lower					
College Variables					
First-term college-level mathematics course					
Passed	0.248	0.101	1.281*	1.055	2.156
Did not pass or take					

Note. *p < .05; [1] Only odds ratios with significant p-value are displayed

Summary

This chapter discussed the results of the research study. The first section described the characteristics of the sample under study, followed by the findings for each of the two research questions. Tables presenting the statistical results were also displayed. A summary of these data, along with conclusions, implications, and recommendations for further research, will be discussed in the following chapter.

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CHAPTER 5: DISCUSSION AND CONCLUSIONS

This chapter summarizes the purpose of the study and details the conclusions drawn from the findings of the research. It presents implications for the study as well as recommendations for future research and for practice.

Purpose of the Study and Research Questions

The purpose of this quantitative, non-experimental study was to examine the relationship between mathematics course-taking, placement, and grade in the first term of college and college student persistence in STEM majors. First-term college-level mathematics course-taking was measured by analyzing whether a student passed, did not pass, or did not take a first-term college-level mathematics course. Persistence in STEM majors was measured by comparing a student's declared STEM major at matriculation with his or her declared major at the end of the sixth college term. The predictor variables under study included gender, race/ethnicity, SES, high school GPA, college mathematics placement, and first-term college-level mathematics course taking. The study sought to answer the following research questions:

1. Are there differences between the characteristics of college students who do and do not persist in STEM majors to the sixth college term?
2. What is the contribution of demographic variables, pre-college variables, and college variables to persistence in STEM majors to the sixth college term?

Conclusions for Descriptive Findings

Descriptive findings from this study complement current literature on STEM retention with similar demographic and pre-college variable differences between students who were retained versus student who were not retained in a

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STEM major in college. Analogous with the research of Alkhawawneh and Hargraves (2014) and Kokkelenberg and Sinha (2010), findings from this study indicated that URM students are often not retained in STEM majors at the same rates as non-URM students. Additionally, this study's findings echo those from Chen & Soldner's (2014) research citing students from low-SES backgrounds as underrepresented in the number of students persisting in STEM majors. Also, consistent with prior research (Chen & Ho, 2012; Moses et al., 2011), findings from this study revealed that students entering college with a high school GPA above 3.00 were retained in a STEM major through their sixth college term at a higher rate than students entering college with a high school GPA of 2.99 or lower. However, this study added to the body of literature on STEM major persistence with the finding that students who passed a first-term college-level mathematics course during their first college term were retained in a STEM major through the sixth college term at a higher rate than students who did not take or did not pass a first-term college-level mathematics course.

Conclusions from the Logistic Regression Analyses

Findings from the logistic regression determined that STEM students who passed a first-term college-level mathematics course and students that entered college with a high school GPA of 3.00 or higher significantly increased their odds of remaining in a STEM major through their sixth college term. While the impact on retention based on student success in a first-term college-level mathematics course *below* calculus had not been previously studied, the results of the logistic regression complement the findings of previous studies that concluded that students who take a calculus course during their first term in college had a significantly higher STEM retention rate than students who did not take a calculus course during their first term in college (Ellis et al., 2016). Additionally, students'

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academic performance during their first year of college positively contributed to STEM major retention through the end of their junior year (Allen & Robbins, 2008). Building on previous research that indicated that success in a mathematics course within a STEM major increased graduation rates for STEM students (Gilmer, 2007), the current study identified a specific term during which an institution can focus on mathematics interventions (i.e., the first college term) for STEM majors.

Results of this study also showed that students who did not take or did not pass a first-term college-level mathematics course were less likely to persist in a STEM major through the sixth college term than students who did pass a first-term college-level mathematics course. Additionally, the logistic regression results found that students who entered college with a high school GPA of 3.00 or higher were significantly more likely to remain in a STEM major through their sixth college term than students with a high school GPA below a 3.00. This finding highlights the importance of student academic performance prior to attending college and supports previous research with similar findings (e.g., Chen & Soldner, 2014). For example, Chen and Ho (2014) previously found that more than 46% of students with a high school GPA below 2.50 left a college STEM major before graduation compared to only 22 % of students with a high school GPA of 3.00 or higher.

Recommendations for Future Research

The findings and limitations of this research suggest several topics for further study. First, it is recommended that this study be replicated at other institutions to provide external validity to the research findings. It is also recommended that more STEM disciplines be included to determine whether the same predictor variables identified in this study (e.g., passing a first-term college-

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level mathematics course, entering college with a high school GPA of 3.00 or higher) also impact retention in a STEM major.

Second, while the relationship between a first-term college-level mathematics course and sixth-term STEM major retention proved significant, it would be worthwhile to explore whether there is a difference in STEM major retention for students that delay taking a college-level mathematics course until their second college term. Additionally, it is recommended that differences in STEM retention be explored for STEM students who opt to not take a mathematics course during their first-college term versus those who do take a first-term college-level mathematics course but do not pass. Lastly, this study only analyzed STEM major retention through the end of a student's sixth college term; therefore, it is recommended that this study be replicated with retention in a STEM major through college graduation as the outcome variable.

Recommendations for Practice

This study was completed at an open access, public, 4-year university. This institution type has seen a continued decrease in the number of students completing graduation requirements for a bachelor's degree over the last 40 years when compared to restrictive-access or private postsecondary institutions (Bound et al., 2010). By focusing on year-to-year student retention through identification of specific academic factors, colleges and universities can implement strategic retention models to increase STEM student graduation rates (Haemmerlie & Montgomery, 2012). Increasing STEM graduation rates should then help fill current and future STEM jobs in the U.S. marketplace (President's Council of Advisors on Science and Technology, 2012). Based on the findings from this study, the following paragraphs will outline five recommendations for practitioners wishing to increase persistence rates for STEM majors.

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First, the results of this study revealed that there were notably decreased rates of STEM major retention for female and URM students. As such, university administrators should work to improve supports for these students in mathematics courses. Other studies have identified ways to increase success rates for underrepresented students in STEM majors, and administrators should mine this literature for practices to implement on their own campuses. For instance, one report on a Midwestern HSI's attempt to improve STEM retention for URM students showed that strategic interventions such as paced science courses, curricular alignment between math and science, a peer mentoring program, and intrusive advising increased STEM retention for URM students (Capi, Ronan, Falconer, Boyd, & Lents, 2013). Moreover, Carlone and Johnson (2007) found that providing female students with peer mentoring and increasing the number of female STEM professors with whom female STEM students can create relationships and increase their science identities was positively correlated with STEM major retention for female students. Apart from those specific strategies, university administrators should also work to help improve female STEM majors' confidence in their STEM abilities. This idea is supported by Ellis et al. (2016), who found that although female STEM students do not actually differ from male STEM students in their academic abilities, female students did exhibit lower confidence in their science abilities, which in turn contributed to lower rates of persistence in STEM majors.

Next, findings from this study showed that students majoring in STEM who do not pass a first-term college-level mathematics course were significantly less likely to persist in a STEM major. In line with previous research that indicates early intervention to improve mathematics skills leads to success in subsequent mathematics courses (Goonatilake & Chappa, 2010; Harrington, Lloyd, Smolinski,

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& Shahin, 2016), it is recommended that university administrators also increase support for STEM students in college-level mathematics courses during their first college semester. For instance, Bressoud et al. (2014) have suggested that colleges and universities offer late-night mathematics tutoring and access to mathematics tutoring in residence halls. In addition, they recommended that mathematics faculty hold their office hours in a mathematics tutoring center.

Regarding faculty, college administrators should also make faculty aware of the relationship between first-term college-level mathematics success and persistence in a STEM major. Doing so may help faculty understand the importance of offering additional support to college freshmen in their beginning college-level mathematics course in their first college term. The results of this study suggest that faculty should embrace offering extra assistance to beginning STEM majors as opposed to the all-too-common philosophy of "weeding out" students who do poorly their first semester.

The university studied in this research project currently does not require students to take prerequisites and does not consider high school GPA before allowing students to declare a STEM major. Because the results of this study describe the importance of high school GPA on retention in STEM majors, it is recommended that the university implement certain scaffolds for students with low high school GPAs (i.e., below 3.00). For instance, the university could require students with low high school GPAs to complete a certain number of STEM courses and obtain a minimum college GPA with at least a "B" average before allowing them to officially declare as STEM majors.

Finally, the findings of this study are specifically relevant to the institution under study, which, as previously noted, is an open access, public, four-year HSI with large numbers of URM and low-SES students. Therefore, university

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administrators from other types of institutions should use this study as a guide for exploring their own institutional data to determine which variables predict STEM retention for their own students. For example, institutions without large populations of URM or low-SES students may find different predictor variables for the effect of mathematics placement, course-taking, and passing rates on student retention in a STEM major.

Summary

This chapter summarized the purpose of the study and detailed the conclusions drawn from the findings of the research. It presented implications as well as recommendations for future research and for practice. The study sought to analyze the predictors of STEM retention through the sixth term of college and found that passing a first-term college-level mathematics course increased a student's odds of persisting in a STEM major.

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