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Student Retention in Community College Engineering and Engineering Technology Programs

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A dissertation

presented to

the faculty of the Department of Educational Leadership and Policy Analysis

East Tennessee State University

In partial fulfillment

of the requirements for the degree

Doctor of Education in Educational Leadership

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by

Harrison P. Orr

December 2019

Dr. Don Good, Chair

Dr. Jill Channing

Dr. James Lampley

Dr. Stephanie Tweed

Keywords: Engineering, Engineering Technology, STEM, Community College, Retention

ABSTRACT

Student Retention in Community College Engineering and Engineering Technology Programs

by

Harrison Orr

An ex-pos-facto non-experimental quantitative study was conducted to examine the academic, financial, and student background factors that influence first-to-second year retention of engineering and engineering technology students at U.S. community colleges. Analysis of the five research questions was done using a chi-square test and multiple logistic regressions. Data were obtained from the National Center for Education Statistics (NCES) Beginning Postsecondary Students 2012/2014 (BPS: 12/14) study. Computations were performed using PowerStats, a web-based statistical tool provided by the NCES, as well as IBM SPSS 25.

The sample population consisted of students who entered postsecondary education for the first time in the 2011-2012 academic year and enrolled in an engineering or engineering technology program at a community college. Predictor variables were identified from the dataset and grouped into the categories of academic, financial, and student background variables. These groupings were used as individual models to predict first-to-second year retention of community college engineering and engineering technology students using logistic regressions. Finally, individual variables that displayed statistical significance were then combined and were used as a model to predict student retention with a logistic regression.

Results indicate that community college engineering and engineering technology students are not retained at a significantly different rate than non-engineering and engineering technology majors. In addition, the groupings of academic and student background variables did not have a significant impact on the retention of community college engineering and engineering technology students, while the grouping of financial variables did have a significant impact on retention. The variables attendance pattern (academic), TRIO program eligibility criteria and total aid amount (financial), and dependency status (student background) were all statistically significant to their respective predictor models. Finally, the combination of these statistically significant academic, financial, and student background variables were significant predictors of retention.

DEDICATION

To my Grandpa, Mamaw, and Papaw, who never saw me complete my studies but always believed that I could do this, even in times when I did not. To my Grandma, who is here to celebrate for them.

To my students, both past and present, who have taught me more than I could ever teach them. Thank you for your endless encouragement during my educational pursuits.

Finally, to my dogs, Kali and Ginger, who had no idea what I was working on but laid next to me on the couch day after day as I wrote this. I needed that.

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I would also like to thank my colleagues from both Southwestern Community College and Asheville-Buncombe Technical Community College for their support and patience throughout the last few years. Ron Poor, Michael Deaver, Justin Hess, Dr. William Brothers, and Daniel Mancuso all had a significant impact on the educator and person I am today. Their insights, support, and cooperation made it possible for me to further my education. I hope that one day I can pay it forward by supporting a student or colleague in their pursuits as much as they supported mine.

Finally, I want to thank my family. My parents, Robert and Kathy Orr, provided me the opportunity to further my educational pursuits without limitation, a gift I did not truly appreciate until many years down the road. My wife, Kaitlyn, has been unbelievably patient with me throughout my graduate studies during a period when many of our peers have already “started their lives.” Well, I can’t wait to finally start ours.

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CHAPTER 1

INTRODUCTION

Community colleges are a vital part of the higher education landscape for a variety of reasons (Linden, 2017; Strikwerda, 2018). Not only do community colleges serve to create skilled and capable workers for trades, they also prepare students for transfer to four-year institutions (Kolesnikova, 2009; Linden, 2017). Strikwerda stated that community colleges are "essential for higher education's goal of serving the national interest" because they provide an "open-door" to higher education for a more diverse group of the population than universities (para. 2).

Within the community college paradigm are Science, Technology, Engineering, and Mathematics (STEM) programs. The STEM categorization is a unified emphasis in academia towards the development of graduates to meet the increasing demand for skilled workers in science, technology, engineering, and mathematics related fields (Thomasian, 2011). STEM programs have been brought to the forefront in recent times because of the increase in employment opportunities in such fields, and community colleges naturally garnered attention for being the de-facto training ground for such labor (Olson & Riordan, 2012; Van Noy & Zeidenberg, 2014).

Development of a sufficient number of workers to fill positions in STEM fields has become a priority among education systems and will continue for some time (Sass, 2015). In a 2012 report, the President's Council of Advisors on Science and Technology (PCAST) concluded the U.S. would need approximately 1 million more STEM graduates by 2022 to retain its status as the world leader in science and technology (Olson & Riordan, 2012).

PCAST proposed transforming the transition between high school and undergraduate education, specifically the first two years of college (Olson & Riordan, 2012). For higher education, focus has been placed not only on recruiting more students for entrance into STEM programs, but on the retention of such students who have already enrolled in such programs (Thomasian, 2011).

Within the scope of the STEM categorization lies the fields of engineering and engineering technology. These programs share the same vision of community colleges as a whole in that they serve to provide students with workforce ready skills (such as inquiry, critical thinking, and problem solving), as well as to prepare students for possible transfer to four-year institutions.

Despite the renewed emphasis on community college STEM programs at the federal level in the past decade, STEM program retention (and therefore engineering and engineering technology retention) remains relatively low. Approximately 20% of community college students declare a STEM major within six years of initial enrollment, but only 30% of STEM enrollees complete the program (Chen & Soldner, 2013). Furthermore, while approximately 6% of community college enrollees majored in an engineering technology program, 62% of students who enrolled in such programs left without obtaining a degree. Therefore, the desire for students to pursue engineering technology programs exists, however an issue of student retention exists as well.

With a renewed nationwide emphasis on community college STEM training, retaining engineering and engineering technology students is paramount to the goal of creating more skilled workers in STEM fields (Olson & Riordan, 2012). Therefore, this research will examine the frequency to which community college engineering and engineering technology students are retained and the factors that influence student persistence in these programs.

Statement of the Problem

The purpose of this study was to examine the academic, financial, and student background factors influencing the retention and graduation of second-year engineering and engineering technology students at community colleges in the U.S. This study identified commonalities among students who persist from their first year into their second in such programs. Identifying factors common among retained students could potentially help community college engineering and engineering technology program faculty better understand why students persist in these programs and could also help tailor support to students who do not display traits that are indicative of persistence.

Research Questions

This study was an investigation into the retention and graduation of engineering and engineering technology students at U.S. community colleges. Specifically, the degree to which students are retained and the factors that contribute to students persisting in engineering technology programs. This study was guided by the following research questions.

1. Is the retention rate for community college engineering and engineering technology programs significantly different than the retention rate of other majors (computer and information sciences, bio and physical science, sci-tech, math, agriculture, general studies and other, social sciences, humanities, healthcare, business, education, undeclared, and other)?

2. To what extent do academic variables (attendance pattern, high school GPA, highest level of high school mathematics, and college credits taken in high school) predict retention of community college engineering and engineering technology students?
3. To what extent do financial variables (employment status, income group, total aid amount, and TRIO program eligibility) predict retention of community college engineering and engineering technology students?
4. To what extent do student background variables (age, gender, dependency status, parent's highest education level, and travel time) predict retention of community college engineering and engineering technology students?
5. To what extent does the combination of academic, financial, and student background variables predict retention of community college engineering and engineering technology students?

Significance of the Study

While data on two- and four-year postsecondary level STEM enrollment and retention exist, data specific to the subset of community college engineering and engineering technology programs does not. The need to understand engineering and engineering technology student retention is underlined by the goal of creating a skilled STEM workforce by 2022 (Olson & Riordan, 2012).

The study of student retention of engineering and engineering technology students will potentially support faculty in advising new and current students. Faculty advisors may have a clearer picture of the students who persist in engineering technology programs and can tailor support to students who appear at risk upon entry to such programs. The factors identified that affect engineering and engineering technology student retention may also help administrators at both the K-12 and community college level design support programs, such as summer bridge programs, to help transition students from secondary education to an engineering technology focused post-secondary education.

Definitions of Terms

To help the reader understand the terminology within this dissertation, key terms have been selected in an effort to further clarify their meaning. Formally defining these terms is necessary to fully comprehend the findings and implications of this report.

Engineering: A field of study in which theoretical knowledge of mathematics and science is applied to develop ways to use materials and resources for the benefit of society (Alexander & Watson, 2014; Pond & Rankinen, 2014).

Engineering Technology: A field of study which that combines scientific and engineering principles with technical skills to solve known problems with existing systems, devices, and components (Pond & Rankinen, 2014).

Persistence: The act of continuing towards an educational goal (Postsecondary Retention and Persistence: A Primer, n.d.).

Retention Rate: The percentage of a given cohort that entered in the fall term and returned to the institution the following fall (Postsecondary Retention and Persistence: A Primer, n.d.).

Limitations

This study of student retention in engineering and engineering technology programs at community colleges was conducted using archival data from the 2012-2014 Beginning

Postsecondary Students (BPS: 12/14) Longitudinal Study produced by the National Center for Education Statistics (NCES) at the U.S. Department of Education (Hill, Smith, Wilson, Wine, & Richards, 2016). The BPS: 12/14 followed-up with students who entered postsecondary education in the 2011-2012 academic year and were eligible for the 2012 National Postsecondary Student Aid Study (NPSAS: 12) (Hill, Smith, Wilson, Wine, & Richards, 2016). The follow-up data included in the BPS: 12/14 was collected via student interviews and archival data (Hill, Smith, Wilson, Wine & Richards, 2016). The limitations of this study are clarified as follows:

1. Due to the use of self-reported data in the BPS: 12/14 and the NPSAS: 12, the data may or may not be accurate.
2. Due to a voluntary nature of the interviews conducted in the BPS: 12/14, the resulting return rate may have been impacted.
3. Because of the multiple methods used to conduct student interviews in the BPS: 12/14, including telephone and web-based responses (Hill, Smith, Wilson, Wine, & Richards, 2016), the resulting data may have been impacted.
4. Because the BPS: 12/14 included voluntary follow-up interviews to the NPSAS: 12 student population (Hill, Smith, Wilson, Wine, & Richards, 2016), some data included in the NPSAS:12 may have been omitted in the BPS: 12/14.
5. Due to the instrument used in the BPS: 12/14 being redesigned since the previous iteration of the study (Hill, Smith, Wilson, Wine, & Richards, 2016), the resulting data may not be comparable to previous BPS studies.

Delimitations

By virtue of the specified group of second year engineering and engineering technology students being studied, a delimitation of this narrow group was identified. The use of multiple-choice survey items limits the answer options for the identified population. The delimitations of this study are clarified as follows:

1. This study is delimited to students majoring in engineering and engineering technology at a community college in the United States. The results may not be applicable to other fields of study at U.S. community colleges.
2. The results may be generalizable to students majoring in engineering and engineering technology fields in U.S. community colleges but may not be generalizable to other school environments.
3. This study is delimited to retention rates of community college engineering and engineering technology students rather than graduation rates. The results of this study may not accurately predict engineering and engineering technology student graduation in U.S. community colleges.

Overview of the Study

This research study is organized into five chapters. Chapter 1 presents an introduction to the study of retention of engineering and engineering technology students at community colleges in the United States. It also provides the statement of the problem, five research questions, significance of the study, definitions of terms, delimitations and limitations, and an overview of the study.

Chapter 2 provides a review of relevant literature and research on the topic of the engineering vs. engineering technology education, the greater emphasis on STEM, and retention models for both engineering technology and STEM students. Chapter 3 provides the methodology of the study, including research questions and null hypotheses, sample, data collection procedures, instrumentation, and data analysis. Chapter 4 provides results of the analysis of data. Finally, Chapter 5 presents a summary, conclusion, and recommendations for practice and research.

CHAPTER 2

REVIEW OF LITERATURE

STEM programs have received considerable attention in recent years because of the national focus on student outcomes and workforce development in such fields (Strikwerda, 2018). Educational systems have taken the approach of integrating studies in these disciplines, creating a centralized ideology known as STEM (Van Noy & Zeidenberg, 2014). STEM programs are defined by the development of critical thinking and problem-solving skills through a pedagogy that focuses on project-based learning and real-world problem solving in the fields of science, technology, engineering and math.

There is rising concern about the rate at which STEM programs are graduating students (Frase, Latanision & Pearson, 2016; Geisinger & Raman, 2013; Sass, 2015). The United States has struggled to keep up with the rest of the world in supplying qualified and skilled workers in STEM fields (Sass, 2015). In order to remain competitive on the global scale, focus must be placed not only on recruitment, but of retention of students in STEM programs (Olson & Riordan, 2012).

The Need for STEM Workers

In 2012, the President's Council of Advisors on Science and Technology (PCAST) stated that the United States needs at least one million STEM graduates by 2022 to remain a world leader in STEM related fields, an increase of 34% annually over pre-2012 rates (Olson & Riordan, 2012). For context, one out of every seven postsecondary education students in the United States will need to earn a degree in science or engineering, while one out of every two students in China will do the same (Soldner, Rowan-Kenyon, Kurotsuchi-Inkelas, Garvey, & Robbins, 2012).

The predicted shortages of qualified STEM graduates entering the workforce can have a “catastrophic” impact on the economy (Hagedorn & Purnamasari, 2012). As of 2012, 26% of the American workforce with a degree in science or engineering is over the age of 50 (Cole, High, & Weinland, 2013). This means that the number of retirees from science and engineering industries will increase rapidly over the next decade. Compounded with the shortage of students choosing STEM careers, this means that the recruitment and retention of STEM students should be of high priority for higher education administrators.

The goal of creating one million additional STEM graduates by 2022 could be achieved without having to recruit additional students if retention rates for STEM related majors across all postsecondary levels were increased to at least 50% (Olson & Riordan, 2012). Institutions often focus on student recruitment rather than retention, even though it costs more to recruit new students than it does to retain the ones are already there (Fike & Fike, 2008). Retaining STEM students provides a lower cost option than developing initiatives to recruit more students, as the population needed to attain the PCAST goal is already in place and many introductory STEM courses are already constrained by classroom space and resource considerations, a problem that would be magnified by a larger enrollment (Olson & Riordan, 2012).

Engineering, Engineering Technology, and STEM

Engineering and engineering technology programs are both hallmarks of higher education STEM curriculum. However, though the two fields of study are similar in many respects, the fields have markedly different objectives (Stephan, Bowman, Park, Sill, & Ohland, 2013). The

National Research Council defined engineering as an "engagement in a practice of design to achieve solutions to human problems" (p. 11). Engineering is a broad, hard to define field requiring knowledge of science and mathematics. The problems posed to engineers usually does not require mastery of the field, but rather the ability to piece together ideas from multiple fields of study (Alexander and Watson, 2014).

The function of an engineer is to design a component, device, or system to solve a new or unforeseen problem, or likewise design a new approach to solve an existing problem (Veenstra, Dey, & Herrin, 2009). As engineering is a profession that creates the latest innovations in technology, engineers are involved in defining and using such technology. Engineers typically possess attributes of ingenuity, creativity, flexibility, analytical thinking, and a dedication to lifelong learning (Stephan et al., 2013).

Engineering curriculum includes components of both science and practice and focuses on the design of complex systems based on broad concepts with a foundation in mathematical theory (Bagherzadeh, Keshtiaray, & Assareh, 2017). Because the engineering student is preparing for a career as an analytical thinker and innovator, the courses that most strongly relate to the engineering mindset are mathematics and science courses (Veenstra, Dey, & Herrin, 2009). Because of the focus on advanced mathematics, community college engineering students can transfer relatively easily into four-year engineering programs upon graduation (Van Noy & Zeidenberg, 2014).

Conversely, engineering technologies occur when engineers "apply their understanding of the natural world and human behavior to satisfy human needs and wants" (NRC, 2012, p. 12). If engineering curriculum is more academic in nature, then engineering technology curriculum is more practical, focusing on applications and skills rather than theory and design

(Stephan et al., 2013). Engineering technology graduates apply their skills towards solving existing problems by installing and troubleshooting components and systems using technical skill. In short, engineering technicians implement, use, and troubleshoot practical applications of the designs made by engineers.

Engineering technology program curriculum focuses on trade-specific skills by the application of acquired knowledge through hands-on activities and implementation of systems (Sadiku, Tembely & Musa, 2015). Engineering technology programs require proficiency in algebra and trigonometry, compared to proficiency in calculus, statistics, and linear algebra required for engineering programs (Sadiku, Tembely & Musa, 2015). Upon completion of a two-year degree, engineering technology program students can usually transfer to four-year institutions or find employment in industry, whereas engineering technology students are more apt to enter the workforce upon graduation (Van Noy & Zeidenberg, 2014). In the workforce, engineering program graduates at all levels of post-secondary education are referred to as engineers, while those in the engineering technology field are referred to as technicians if they have an associate degree or credential, or technologists if they attain a bachelor’s degree or higher (Kuehn, 2017).

Demographics of Engineering and Engineering Technology Students

Van Noy and Zeidenberg (2014) provided an overview of the demographics of students enrolling in STEM majors at community colleges. The researchers divided the spectrum of STEM majors into two categories: science and engineering, and technician (engineering technology) programs. The choice to distinguish engineering and engineering technology programs from each other is of interest as both fields of study attract two different types of students (Kuehn, 2017; Lucietto, 2017; Van Noy & Zeidenberg, 2014). In community college engineering programs, which are generally targeted towards transfer into four-year institutions, 83% of science and engineering students were the traditional college student age of 18-24 years old (Van Noy & Zeidenberg, 2014). By contrast, engineering technology programs, which focus on the development of trade specific skills as opposed to transfer, had only 66% of students in the same age bracket.

Though community college STEM programs are disproportionately white (65%) at the community college level, technology programs have even less diversity (68% white) than science and engineering programs (61% white) (Van Noy & Zeidenberg, 2014). African-American students chose technology programs (13%) over science and engineering programs (8%), while Asian students were more likely to choose science and engineering programs (11%) over technology programs (4%). Hispanic students were almost evenly split between choosing technology programs (12%) and science and engineering programs (15%).

Community college technology programs also lagged far behind science and engineering programs in the enrollment of female students. Only 24% of community college technology program students were female, compared to 40% of science and engineering majors (Van Noy & Zeidenberg, 2014). As a whole, STEM programs had a female enrollment rate (30%) that was less than half than that of the entire community college population (62%).

Though their populations were different in makeup, Van Noy and Zeidenberg (2014) found that both science and engineering programs and technology programs were similar in percentages of full-time, part-time, and mixed enrollment. In general, community college students are more likely to attend part-time and work full-time outside of school (Horn & Nevill, 2006). However, a disparity exists between science and engineering and technology programs in the employment patterns of students while enrolled in such programs. Seventy-six percent of community college STEM students were employed outside of school compared to 55% of STEM students at four-year institutions (Van Noy & Zeidenberg, 2014). Overall, community college STEM students worked on average 11 more hours per week than STEM students at four-year institutions. In addition, both fields of study were generally similar in the number of breaks, or "stop-outs" a student would take throughout the six-year period of the study.

Enrollment in Engineering, Engineering Technology, and STEM Programs

Chen and Weko (2009) examined the persistence of students enrolled in STEM programs at both the community college and university level, beginning with the 1995-1996 academic year and tracking their progress over the next six years. Of all students entering postsecondary education in the 1995-1996 academic year, 22.8% chose a STEM major, including 8.3% who enrolled in an engineering technology major. In the field of engineering technology, 42% of students enrolled at a community college while 47.8% enrolled at a four-year institution.

A follow-up report by Chen and Soldner (2013) outlined the persistence of students in STEM majors between the 2003-2004 academic year through 2009, but with data specific to community college students. Twenty percent of all associate degree seeking students enrolled in a STEM major, including 6% who enrolled in engineering and engineering technology programs. Engineering and engineering technology were second only to computer/information sciences in STEM program enrollment, and together these fields of study accounted for 15% of all community college enrollees.

In a nationwide study of the engineering technology enrollment at four-year institutions, Lucietto (2017) found that the majority of STEM students enroll in engineering-based majors as opposed to engineering technology, science, and math programs. Lucietto stated that the nationwide engineering technology population "represent a small group of students as compared to traditional engineering" (p. 8). However, Van Noy and Zeidenberg (2014) found that 10.2% of community college students enrolled in a technology program at some point between 2003 and 2009, compared to 6.6% of science and engineering students. Thus, a disparity exists between engineering and engineering technology enrollment at the community college and university level.

Retention in Engineering, Engineering Technology, and STEM Programs

In general, students who choose to leave STEM majors follow one of two paths; either switching from a STEM major to a non-STEM major or dropping out of college altogether (Chen & Soldner, 2013). As far back as the 1990s, retention issues for engineering and engineering technology programs can be identified. An NCES study tracking first year students from their initial enrollment in 1990 found that 20% of science and engineering students had dropped out of college, approximately 30% had transferred to other majors, and fewer than half who enrolled had completed a degree in a science and engineering field (Huang, Taddese, & Walter, 2000).

In recent times, Chen and Soldner (2013) found that 69% of community college students who enrolled in a STEM major between 2003 and 2009 had left their STEM major by 2009, 21% higher than the rate for bachelor's degree seeking students. Of the students who left their STEM major, 33% switched their major to a non-STEM major while 36% dropped out of college altogether. Though the 69% attrition rate for community college STEM majors is relatively large, it was consistent with other fields of study at the community college level including social/behavioral sciences (68%), education (70%), business (66%), and humanities (72%). Nationwide community college overall graduation rates are relatively low, and these low rates are often attributed to community colleges enrolling a higher number of low-income, academically underprepared, non-traditional, and minority students (Martin, Galentino, & Townsend, 2014).

Looking specifically at the engineering and engineering technology subsets, 62% of engineering technology students who enrolled at a community college in 2003-2004 had left their major by 2009, an increase of 28% over students enrolled in engineering and engineering technology programs at the university level (Chen & Soldner, 2013). Of those that left engineering and engineering technology, 22% had switched to another major while some 40% had dropped out of college altogether. Though the rate at which community college engineering and engineering technology students switched to non-STEM majors was consistent with the same rate at the university level, community college engineering technology students were twice as likely to drop out as those at the university level (40% versus 20%).

Van Noy and Zeidenberg (2014) showed that technology programs had a significantly higher dropout rate than science and engineering programs; 41% of students dropped out of technology programs compared to only 27% of science and engineering students. However, the higher dropout rate for technology programs was somewhat offset by the fact that technology programs had a lower number of students (29%) switch to non-STEM majors than that of science and engineering programs (39%).

Within six years of enrollment, 37% of science and engineering students transferred to a four-year university with 16% obtaining a bachelor's degree (Van Noy & Zeidenberg, 2014). By contrast, only 19% of technology students transferred to a four-year university, with 7% earning a bachelor's degree. The discrepancy in transfer rates between science and engineering and engineering technology programs is partially caused by the mathematical requirements for technology programs, which do not adequately prepare students for four-year engineering programs, which generally require proficiency in calculus and above (Sadiku, Tembely & Musa, 2015).

Graduation in Engineering, Engineering Technology, and STEM Programs

Overall, the number of associate degrees awarded in engineering technology has been trending down from a peak of nearly 50,000 in 1989 to approximately 25,000 in 2014 (Frase, Latanision, & Pearson, 2017). However, since 1990 the number of certificates and credentials awarded have increased from a low of approximately 10,000 in 1991 to nearly 50,000 in 2014.

Out of all STEM students who entered postsecondary education in the 1995-1996 academic year, 37% graduated with a degree or certificate by 2001 while 55% left their STEM program (Chen & Weko, 2009). Of the 55% that left, an almost even split (27% vs 28%) was observed between those who switched to non-STEM majors and those who left school altogether. By 2009, 30% of technology students persisted in their major by earning a degree or being still enrolled (Van Noy & Zeidenberg, 2014). An almost equal number of technology program enrollees (29%) attained a degree or certificate in a non-STEM major, and 41% dropped out of college altogether.

Between 1996 and 2001, approximately 41% of engineering and engineering technology students graduated with a degree or certificate, slightly higher than the overall graduation rate for STEM programs (Chen & Weko, 2009). However, 23.1% of students who originally enrolled in an engineering or engineering technology program obtained a degree in a non-STEM major, approximately 28% dropped out of college altogether, and 9% were still enrolled in 2001.

The Theoretical Framework of Higher Education Retention

Bean's Student Attrition Model, developed in 1979, was the first retention model for higher education developed from studies of employee turnover in industry; student retention and employee turnover are analogous, and both occur for similar reasons (Aljohani, 2016; Bean, 1979). Bean stated that employees leave their workplace primarily due to issues with quantitative (pay) and qualitative (satisfaction) variables. In the case of higher education, student retention is predicted by both quantitative (GPA) and qualitative (intellectual development, institutional quality, and perception of practical value) variables (Aljohani, 2016; Bean, 1979).

Though Bean's Student Attrition Model has been generally accepted as a valid model for student retention, the model that has gained the most notoriety is Tinto's Student Integration Model (SIM) (Demetriou & Schmitz-Sciborski, 2012). Demetriou and Schmitz-Sciborski stated that Tinto's work is "what started the national dialogue on student retention in higher education" (p. 1) and that the model "remains a seminal theory important to the field" (p. 10), while Swaim (2004) stated that the model is the "dominant sociological theory of how students navigate through our postsecondary system" (p. 3). Veenstra, Dey, and Herrin (2009) called Tinto's model "the most tested and accepted" model of college student retention (p. 2).

Tinto theorized that students drop out of postsecondary education due to the extent of their integration into the institution, with integration being an amalgamation of their academic, environmental, and societal experiences and being dependent upon the student's individual characteristics (skills, dispositions, financial resources, and prior educational experiences) (Tinto, 1993). The stronger a student integrates into the institution, a two-way effort of both the student and the school, the stronger the commitment to persistence is for the student (Tinto, 1993).

The primary criticism of Tinto's model is that it only applies to traditional college students (McCubbin, 2003). Tinto's research was conducted on traditional college students at four-year universities, and those student's personal ecosystem is centered on the campus as it is not only their place of learning, but also their home. More opportunities exist for students to integrate with the institution than if the student commutes from an off-campus residence, as is the case in community college education.

In addition, students who are not of traditional college age (18-21), are more likely to have a well-defined emotional support structure outside the host institution and may not need or want to become socially integrated into the campus (McCubbin, 2003). In other words, because they get the emotional support from their home life or co-workers, they typically only integrate academically with the institution. This means that Tinto's model may not be entirely applicable to the community college realm as such institutions are non-residential and have a significantly large non-traditional student population (McCubbin, 2003). However, it is worth noting that approximately 50% of four-year STEM program graduates took some community college courses in their pursuit towards a baccalaureate degree (Snyder & Cudney, 2018).

Tinto's model has also been criticized for its applicability to minorities. Torres and Solberg (2001) applied the SIM to a Latino postsecondary student population (of which approximately a third were community college students) and found that social integration had no effect on retention.

However, McCubbin (2003) concluded that it is impossible for one singular retention model to be designed to account for "every conceivable reason that every single departing student had for leaving higher education" and, therefore, a model that can "effectively describe the attrition behavior of the traditional student type will still have been a remarkable success" (McCubbin, 2003, p. 4). Tinto has continued to adjust his model from its initial framework and remarked that the model will not explain all facets of non-completers in specialized collegiate settings (Tinto, 1982).

Veenstra, Dey, and Herrin (2009) proposed a model of freshman engineering student retention that is based on Tinto's Student Integration Model. The freshman engineering retention model is slightly different from Tinto's model as in addition to predispositions and attitudes about education, it includes quantitative skills to form the pre-college characteristics of the student rather than pre-college experiences.

As students persist through the first-year, they define their academic integration by their level of performance, a feeling that manifests itself through the student's first-year GPA. Therefore, the interaction of academic and social integration defines what the student gets out of, or learns, from their freshman year experience (Veenstra, Dey, & Herrin, 2009). Throughout the freshman year experience, a typical student will re-evaluate their commitment to the host institution and to engineering education at the host institution and alter their career and educational goals accordingly. This commitment is a product of the student's academic and social integration into the institution, not just academics alone.

Factors Influencing Engineering, Engineering Technology, and STEM Retention

The use of Tinto's SIM as a lens to view engineering and engineering technology retention is also bolstered by the work of Xu (2015). Xu stated that the common link between STEM program retention and overall retention in higher education is the interaction of the student with the institute, whether that be a sociological, cultural, organizational, or psychological interaction (Xu, 2015). Integration into the institution is more than purely academic; specifically, student retention is the product of the student's integration of individual commitment to completing college and their individual commitment to the institution that determines their persistence (Tinto, 1993).

Tinto noted that a significant number of students who drop out are not doing so due to academic challenges. Voluntary non-completion of higher education is often seen in intellectually developed students, as opposed to students dismissed due to poor academic performance (Tinto, 1993). Therefore, student persistence isn't purely determined by academic performance and includes a component of the student's integration into the ecosystem of the campus through opportunities for engagement, academics, networking with peers, and faculty interaction (Tinto, 1993).

The application of Tinto's model to the engineering and engineering technology subsets is determined not just by Xu (2015). Geisinger and Raman (2013) also reinforced Xu's assertion, albeit indirectly, that Tinto's model can be applied to the engineering and engineering technology subset. They stated that students who are leaving engineering are often doing well academically and aren't leaving for academic reasons, a view shared by Tinto in his model of general student retention and validated in the engineering subset by Seymour and Hewett (1997).

Geisinger and Raman (2013) provided factors that contribute to students leaving engineering and engineering technology programs that go beyond pure academics including an unwelcoming climate, a lack of self-confidence, feelings of individualism and isolation, losing interest and commitment, and sexism and racism. These findings concur with Tinto, who found that positive feelings of confidence and belonging in academia coupled with social acceptance from peers tends to increase the integration of the student into the campus community (Tinto, 1993). Laguador (2013) agreed with Tinto's assertion, stating that students who show low interest and motivation to face academic challenges in engineering are more likely to shift to other degree programs, and that engineering students who are retained "realize the value of perseverance and commitment towards their work" (p. 83). As Tinto concluded that a student's predispositions to academics are retained from secondary to postsecondary education, Laguador stated that the habits practiced by a student during college are likewise indicative of their habits they will display in their professional career upon leaving school.

Seymour and Hewett (1997) concurred with Geisinger and Raman that students who leave engineering majors are not academically different than the ones who stay, but rather leave due to the culture and career expectations of engineering programs (Seymour & Hewett, 1997). However, Zhang, Min, Ohland, and Anderson (2006) observed many academic differences between engineering students who are retained and those who are not. They posited that students who perform well academically and still leave engineering programs must do so because of non-academic factors, as less than 15% of all matriculated engineering students with a GPA over 3.0 leave engineering. Those who leave engineering with a high GPA typically leave after the first year, while those who have a low GPA typically leave such programs during the first year.

Academic performance and level of mathematics classes taken at the high school level are both predictors of student academic performance in STEM majors in college (Van Noy & Zeidenberg, 2014; Camacho, 2015). Engineering and engineering technology attrition may be the result of a disconnect between the culture and curriculum within high schools compared to those at the community college level (Cole, High, & Weinland, 2013). Many high school graduates are academically underprepared to study engineering in college because they have not taken a sufficient number of math, science, and technology-based courses in high school (Yurtseven, 2002). Of the students who entered community college STEM programs with a GPA of 2.5 or less in high school, 41.8% eventually dropped out of college and 36.3% switched to a non-STEM major (Chen & Soldner, 2013). Approximately 47% of STEM students who did not take any higher-level mathematics course (algebra II, trigonometry, pre-calculus, and calculus) in high school dropped out of college while only 28.7% of students who took advanced level math courses in high school dropped out of college (Chen & Soldner, 2013).

However, as discussed earlier, the 2013 report by Chen and Soldner includes both community college and undergraduate students in its population. Traditionally, four-year engineering students have a pattern of enrolling in advanced science and mathematics courses in high school (Cole, High, & Weinland, 2013). Community colleges provide a low cost and open enrollment opportunity for millions of underprepared and low-income students (Quarles & Davis, 2016). Therefore, many community college students have been out of school for years or performed poorly in college-like courses in high school (Costello, 2012). Approximately 58% of students enrolling at a community college will be placed in some form of remedial education (Cullinan, Barnett, Ratledge, Welbeck, Belfield, & Lopez, 2018).

The percentage of community college STEM students needing remedial or developmental classes at the community college level is 69%, more than double that of the university level (31%) (Van Noy & Zeidenberg, 2014). In addition, 64% of students in the science and engineering subset needed remedial or developmental courses compared to the 72% for technology majors. The higher rate of technology students needing remedial or developmental courses than science and engineering is not surprising, given that technology programs had a higher percentage of older students than science and engineering majors.

Being placed into remedial math and/or English courses upon arrival to postsecondary education elongates the time to complete a degree (Camacho, 2015). Remedial courses typically have low completion rates, particularly for math courses, which have a completion rate of approximately 30% (Bailey, Jeong, & Cho, 2010). Failing courses also elongates the time to complete a degree and failing early core curriculum engineering and engineering technology classes has been shown to be a deterrent for succeeding in future courses (Laugerman, Shelley, Rover, & Mickelson, 2015). Failing an engineering course causes the student to question if the degree is right for them (Suresh, 2006).

Also notable is the comparison of academic success in core curriculum classes in STEM programs that of non-STEM classes. Of the community college STEM majors who dropped out of college, 37% had a GPA in STEM courses that was 0.5 or more grade points below their GPA for non-STEM classes, compared to only 3% of those who persisted in their STEM major (Chen & Soldner, 2013). For those who switched to non-STEM majors, 26% had a GPA 0.5-1.0 grade points below their performance in non-STEM classes (Chen & Soldner, 2013).

Though academic performance does not necessarily paint a clear picture of retention, it is clear that it is a part of the discussion. However, Felder, Felder, and Dietz (1998) explained that it is incorrect to blame student's inability to cope with the rigors of engineering programs for high attrition in such concentrations. The full picture of engineering attrition is illustrated by the combination of student's attitudes towards their education, self-confidence, the quality of instruction, and the quality of their interactions with peers.

Self-confidence, primarily through the lens of self-efficacy, is a common theme among engineering, engineering technology, and STEM retention studies at all levels. Painter and Bates (2012) stated that persistence through education may be explained by self-efficacy, or the belief in one's self to persevere. A student with low self-efficacy sees a bad academic performance as an effect of personal knowledge and ability, while a student with high self-efficacy views the same performance as an effect of insufficient studying (Painter & Bates, 2012). Support and encouragement from faculty can instill a higher level of self-perceived ability, which in turn positively influences self-efficacy and persistence.

Differences in self-efficacy are readily apparent between students who took pre-engineering coursework or have a background of engineering hobbies and students who did not have such experiences (Fantz, Siller, & Demiranda, 2011). Students who participated in technology education classes and pre-engineering coursework had significantly higher self-efficacy scores (Cole, High, & Weinland, 2013). Bringing prior experience in engineering, either through pre-college coursework or through individual hobbies, impacts the student's belief in their ability to do engineering coursework and college (Fantz, Siller, & Demiranda, 2011).

Engineering and engineering technology are generally considered to be more academically difficult higher education degree programs due to the rigor of the coursework and the deeper level of math knowledge and skill needed for success (Laguador, 2013). A qualitative inquiry of the STEM faculty viewpoint of student struggles by Gandhi-Lee, Skaza, Marti, Schrader, and Orgill (2015) indicated that a lack of mathematical knowledge is a significant barrier to student success. Students with a stronger math background will have a competitive advantage over those who have a weaker math background (Veenstra, Dey, & Herrin, 2009), and Laugerman, Shelley, Rover, and Mickelson, (2015) stated that characteristics indicative of persistence in engineering programs include high performance in pre-college mathematics.

Engineering programs are math intensive and faculty working in such disciplines prefer that students take at least pre-calculus before entering an engineering program, though a proficiency in algebra would suffice (Gandhi-Lee et al., 2015). Felder, Felder, and Dietz (1998) cited quality of instruction as a factor in student attrition, and mathematics faculty have direct impact on the student's perceptions of math difficulty (Laguador, 2013). Therefore, Laguador challenged faculty teaching mathematics to encourage and motivate students to aspire for academic success and prepare for more rigorous coursework at a four-year institution.

But perhaps the perception of math education is a greater deterrent to retention than the actual math education process. Approximately 20% of faculty surveyed cited a "fear of math" as a significant obstacle to student success in mathematics (Gandhi-Lee et al., 2015). This sense of fear is compounded throughout primary and secondary education by the perception by students that math is too difficult. Community college engineering and engineering technology students who plan to transfer to a university upon graduation are recommended to take up to Calculus II before transferring, further compounding the problem of the perception of math difficulty on this subset of students (Laugerman, Shelley, Rover, & Mickelson, 2015).

Overcoming the "fear of math" is a difficult challenge, as many students lose interest as soon as mathematical concepts are introduced into STEM coursework. Community college STEM students self-indicated they had low self-efficacy for mathematical calculation, statistical modeling, and several areas of technical knowledge (Baker, Wood, Corkins, & Krause, 2015). However, they expressed high self-efficacy in the areas of written and oral communication skills and critical thinking, and reading aptitude was shown to be a significant factor in STEM retention (Baker, Wood, Corkins, & Krause, 2015).

Christie (2015) discussed seven themes that emerged through phenomenological interviews with engineering technology majors who persisted from the first to second year. These themes include personal goals, classmate collaboration, faculty relationships, uneasy beginning, work effort, adaptability, and campus involvement (Christie, 2015). Of interest is classmate collaboration, a form of peer interaction which Felder, Felder, and Deitz (1998) identified as a factor affecting student attrition. In STEM fields, collaborative learning techniques have been demonstrated to influence student persistence (Springer, Stanne, & Donovan, 1999). Students who never study with their peers are less likely to be retained than students who study collaboratively. Likewise, students who work on their homework independently are less likely to be retained than those who work collaboratively (Honken &

Ralston, 2014). Peer interaction is important to persistence and self-efficacy in college students as identifying with peers may be reflected as a vicarious experience, particularly for female and minority students (Painter & Bates, 2012).

Tinto (1993) also stated that students who devote the majority of their free time to academics are decreasing their opportunity to integrate socially with their peers, while those integrating socially with their college peers would be inadequately integrating academically. While it is well documented that Tinto's retention model is based on traditional college students (McCubbin, 2003), the idea of social distractions taking away from academic performance (and vice-versa) can apply to the community college realm if a student's social responsibilities (family, career, etc.) are considered. Van Noy and Zeidenberg (2014) found that community college STEM students worked on average 11 more hours per week than STEM students at four-year institutions. In a study on a two-year mechanical engineering technology program, Mulski (2016) stated that the number of hours a student works outside has a significant impact on retention. Mulski opined that schools should educate students on the perils of working too many hours outside of school in addition to offering flexible class scheduling and alternative teaching methods.

The Faculty Component

Marra, Rodgers, Shen, and Bogue (2009) stated that the three biggest factors involved in engineering program retention are poor teaching and advising, difficulty of curriculum, and the feeling of a "lack of belonging." Similarly, Cole, High, and Weinland (2013) stated that program difficulty, lack of skills, poor academic performance, and poor instructional quality are common factors associated with engineering program attrition. The President's

Council of Advisors on Science and Technology pointed to an "unwelcoming atmosphere in introductory STEM courses" and put the blame squarely on educators (Olson & Riordan, 2012, p. 9). Fike and Fike (2008) stated that for any faculty or administrator wanting to make a difference in the lives of their students, understanding why students choose to leave or stay in higher education is essential. Soldner et al. (2012) opined that if our long-term prosperity as a society is linked to the education of workers in STEM fields, then it is time for a "renaissance" in STEM education.

Perera, Quinlivan, and Zastavker (2013) divided faculty teaching in STEM majors into two general categories: personal coaches and group ushers. So-called group ushers view their job as simply moving students forward to their next classes, and view teaching as a job instead of a life calling. Group ushers view students generally as a whole instead of individually and tend to avoid one-on-one interaction with students.

Alternatively, personal coaches seek to create a comfortable environment for learning and build up confidence in their students with supportive behavior (Perera, Quinlivan, & Zastavker, 2013). Personal coaches seek out one-on-one interaction with students because they believe in the value of such interaction. Overall, personal coaches are concerned with the long-term outlook for their students, and do not view their job as to simply move students on to their next courses. Personal coaches take a genuine interest in the outcome of their students, both in and after college. Personal coaches also tend to use project-based learning as a teaching method more than group ushers. Perera et al concluded that the approach of personal coaches leads to more desirable outcomes for STEM students than the group usher approach.

STEM faculty observed that successful students possessed the qualities of curiosity, good written and oral communication skills, problem solving skills, and strong work ethic

(Gandhi-Lee, Skaza, Marti, Schrader, & Orgill, 2015). Martin, Galentino and Townsend (2014) found commonalities among graduates including clear goals, strong motivation, a drive to succeed, ability to handle external demands, and a sense of self-empowerment. Faculty working in STEM programs placed more value on problem solving skills and a general curiosity for subject matter than on skills specific to individual disciplines (Gandhi-Lee et al., 2015). Nearly 20% of faculty interviewed as part of the study indicated that they could develop discipline-specific skills within students if the students possessed problem solving skills and displayed a general curiosity for the subject matter (Gandhi-Lee et al., 2015).

Much research exists into the effects of instruction on STEM program retention. Cabrera, Colbeck, and Terenzini (1998) found that teaching style played a bigger role in predicting student success than pre-college preparation. Some faculty members consider high attrition to be unavoidable in STEM education and enjoy the challenge of separating the "good" students from the "bad," a process commonly referred to as "weeding out" (Geisinger & Raman, 2013). Veenstra, Dey, and Herrin (2009) opined that the combination of the tradition of "weeding out" weaker students in first-year engineering courses as well as the expectations of a career that requires competitive behavior fosters competition among students and leads to a lower first-year average GPA, something that Zhang, Min, Ohland, and Anderson (2006) stated leads to higher first-year attrition in such programs.

Xu (2015) noted that poor teaching skills in STEM courses, such as engineering and engineering technology, obscure the course subject matter and often diminishing students' confidence and interest in the topic, discouraging them from pursuing further courses. Xu also stated investing in improving faculty teaching skills, reducing class sizes, and using active learning techniques to improve engagement and participation will help improve STEM student retention.

Astin (1993) found when comparing engineering majors to other fields, engineering students were much more dissatisfied with not only the quality of instruction, but with their overall college experience. The feelings of dissatisfaction of engineering majors was primarily due to the reliance on lecture-based teaching methods and curved grading scales that artificially inflate students' performance on assessments. However, this research was conducted before the rise of educational technology and virtual learning environments brought on by the rise of the internet.

The issue of increasing STEM retention is rather complex in nature as it involves not only higher education, but public schools as well. Strimel and Grubbs (2016) stated that the "failure to align technology and engineering education with the engineering profession has caused technology and engineering education to continue to lose a foothold within local education systems" (p. 27). Strimel and Grubbs opined that the proverbial STEM pipeline, which is already rather "leaky" due to student attrition, is also clogged by a lack of alignment amongst postsecondary and secondary educators (Veenstra, Dey, & Herrin, 2009).

Of note was Strimel and Grubbs (2016) statement that many secondary level educators teaching engineering and engineering technology subjects have never taken college level courses in those fields, as they are not required to for their job. To ensure a standard of quality in secondary engineering technology programs, and to adequately prepare students for entry to such programs in college, a nationwide engineering teaching licensure was proposed (Strimel & Grubbs, 2016).

The lack of qualified instructors at the secondary level has resulted in some school systems dropping the "technology" from engineering technology curriculum and focusing on science-based engineering curriculum that leaves students ill-prepared for the practical applications of engineering technology curriculum in addition to steering students away from enrolling in such programs at the postsecondary level (Strimel & Grubbs, 2016). To combat this, they implored postsecondary engineering technology educators to work closely with science educations, particularly at the secondary level, to replace "less authentic" science classroom activities that use "unrealistic materials, such as popsicle sticks, cardboard, duct tape, and hot glue" with industry quality strategies (p. 27). This is not new, as PCAST implored the diversification of teaching methods, such as project-based learning, to increase student engagement (Olson & Riordan, 2012). Strimel and Grubbs (2016) also suggested that pre-engineering and engineering technology curriculum, if employed in secondary schools, cater to both subjects through a core of mathematics, physics, and science before progressing toward engineering technology subjects such as analog and digital circuits and mechanical system design.

Retention Strategies for Underrepresented Students

As stated previously, community colleges provide a low cost and open enrollment opportunity for millions of underprepared and low-income students (Quarles & Davis, 2016). Community colleges differ from their university brethren as they are more agile and responsive to local market demands (Snyder & Cudney, 2018). As community colleges are commuter campuses, students at such schools are more reflective of the region in which the college is located, whereas universities draw students from throughout the state or neighboring states and are typically regionally focused in their scope.

The low cost and open accessibility of community colleges allow these schools to be an entry point to higher education for minority students (Costello, 2012). The NC STEM Center characterized successful STEM education programs as those who use project-based learning integrated across multiple subjects, offer supplemental out-of-school programs, integrate virtual learning into the classroom environment, provide professional development opportunities and provide outreach to underrepresented demographics, such as female and minority students (North Carolina's Science, Technology, Engineering, and Mathematics (STEM) Education Strategy, 2011)**.** Though an open door exists for minority and female students at the nation's community colleges, engineering and engineering technology programs have traditionally experienced high attrition and low completion for minority and female students (Hill, Corbett, & St. Rose, 2010; Kendricks, Nedunuri, & Arment 2013; Marra, Rodgers, Shen, & Bogue 2009).

The underrepresentation in enrollment and high attrition of female and minority students in STEM programs has also been widely documented (Kendricks et al., 2013; Marra et al., 2009; Olson & Riordan, 2012; Hill, Corbett, & Rose, 2010). PCAST stated that engaging minority students, specifically Hispanic and African-American students, is critical to the goal of reaching one million STEM graduates by 2022. Minority students make up approximately 70% of postsecondary enrollment yet are traditionally underrepresented in STEM related programs (Olson & Riordan, 2012).

The 2013 report by Chen and Soldner provided key insight into the demographics of students who chose to leave STEM programs. Among associate degree seeking students, 42.6% of women had left their STEM major for a non-STEM major, while nearly 29% of men had done the same. The opposite is true for those who dropped out of college altogether, where nearly 33% of women dropped out compared to 38% of men. Asian and Caucasian students were less likely to drop out than any other ethnicity by nearly 10% in comparison to African-American and Hispanic students.

Though Van Noy and Zeidenberg, (2014) showed that engineering technology programs have been proven to be whiter than engineering programs, Kuehn (2017) opined that engineering technology is more successful in recruiting minority students than engineering. Kuehn speculated that this is the case due to the engineering technology offering an easier route to a STEM workforce rife with jobs with its easier math core and more practical approach than engineering (Kuehn, 2017). After all, Tinto (1993) argued that retained students tend to view higher education as a pathway towards future success as determined by their personal goals; if their education experience is not significantly helping them towards reaching that goal, then the student will most likely drop out. However, a student's education experiences are influenced as much by the student's individual attributes (race, sex, intelligence, social status and academic prowess) as it is the quality of the institution (Tinto, 1993). Kuehn contended that engineering technology programs should be cultivated as an entry point for minority students in STEM education as such programs allows these students a quick and unrestricted path to a solid career (Kuehn, 2017).

Hill, Corbett, and Rose (2010) expanded the reasoning for female students leaving STEM programs, as well as the steps that can be taken to address the problem. Negative stereotypes against women, even at an early age, have a direct impact on their motivation in pursuing a degree in a STEM field. Based solely on their academic performance, female students are less likely than males of similar academic performance to feel prepared for the workplace (Hill, Corbett, & Rose, 2010). Steele (2010) noted that female math majors perform worse on tests due to the presence of embedded gender stereotypes. Tinto (1993) stated that males place more value on quantitative performance measures, such as individual grades and GPA's, while females tend to place more emphasis on qualitative measures of intellectual development. Therefore, Tinto postured that male students are more likely to persist in higher education than females, but also noted that females are more likely to voluntarily drop out of college rather than be dismissed due to academic performance. The use of positive reinforcement and encouragement to build the confidence of female students helps to instill the belief in female students that they can be successful in STEM careers (Hill et al., 2010). In addition, engineering and engineering technology programs can better motivate female students by providing real-life examples of the societal benefits of engineering, as female students tend to recall material quicker than men when they believe the material is socially relevant (Bossart & Bharti, 2017; Ro & Knight, 2016).

The same disparity that exists between the perception and reality of higher education for female students also exists among racial minorities. Because of racial stereotypes, minority students who are academically underprepared in their STEM major are more likely to associate this feeling as a personal shortcoming as opposed to a failure of primary and secondary education to adequately prepare them (Marra, Rodgers, Shen, & Bogue, 2009). African-American students in particular tend to see a poor academic performance as indicative of a common stereotype that they are somehow less intelligent than Caucasian students, though studies have shown that when this bias is controlled for both races produce similar results in testing scenarios (Silver, 2011; Steele 2010). These thoughts of inadequacy alter future academic performance and decision making and can produce stress and stress related health consequences, compounding negative emotions towards enrolling in future semesters.

Marra et al. (2009) argued that a greater emphasis on mentoring is needed to better academically and emotionally support underrepresented students, a viewpoint shared by other studies on the topic (Johnson, 2013; McClain & Perry, 2017). Minority students have shown greater academic success when supported by minority specific mentoring programs (Kendricks, Nedunuri, & Arment, 2013; LaVant, Anderson, & Triggs, 1997). Minority-only mentoring programs can be implemented at little to no cost (through the use of existing minority faculty and students) and help support minority students by promoting feelings of community and acceptance. Painter and Bates (2012) found that students with positive influences and high science self-efficacy beliefs, regardless of race or gender, are more likely to increase their effort to succeed in STEM activities, whereas students with low science self-efficacy beliefs are more likely to put forth less effort and avoid STEM activities.

Hill et al. (2010) also stated that performance expectations should be made with clarity because of the likelihood of lower than average test scores in STEM courses compared to non-STEM course. Performance expectations are not made clear, female students may resort to perceptions related to stereotypes to evaluate their academic performance, when in reality the student may not be performing poorly given the nature of the course (Hill et al., 2010). Female engineering students often earn higher grades than their male counterparts and feel that they must do so in order to prove themselves (Orr, Ngambeki, Long, & Ohland, 2011). The perception of lower academic performance caused by lack of clarity of performance expectations can add to the feeling of "lack of belonging" for female students that may have already been instilled by negative stereotypes (Hill et al., 2010).

Minority students also cited a “lack of belonging” as a factor for deciding to leave engineering, more so than poor teaching and curriculum (Marra, Rodgers, Shen, & Bogue, 2009). However, all three factors weighed more on the decision of minority students to leave engineering than Caucasian students. The feeling of “lack of belonging” is directly linked to the feeling of confidence, or lack thereof, of completing an engineering program. This supports the findings of Hill et al. (2010) that positive reinforcement to build confidence has a positive impact on student, particularly minority and female student, outcomes in engineering programs.

Besides mentoring programs, community college engineering and engineering technology departments can attempt to create an inclusive environment for women and minorities through initiatives such as creating chapters of “women in engineering” groups and sponsor social events and seminars (Hill et al., 2010). These initiatives aid in the integration of female and minority students into the department as well as to showcase a positive image of inclusion and equality. Long term goals of community college engineering and engineering technology programs should be a more balanced gender and racial representation in faculty (Kerkhoven, Russo, Land-Zandstra, Saxena & Rodenburg, 2016). Guiffrida (2005) found that African-American students willingly sought courses with professors of color as a comfort mechanism in support of their academic pursuits. Female and minority instructors could serve as spokespersons for their respective programs and lecture to primary and secondary students about pursuing a career in an engineering discipline, as the interaction between successful females working in STEM fields and children helps to break these negative stereotypes of women working in STEM fields at a young age.

The advantage of retention strategies that aid female and minority engineering and engineering student retention is that they are also applicable to all engineering and engineering technology students (Lichtenstein, Chen, Smith, & Maldonado, 2013). These broad strategies include promoting student integration within the department and the institution, showcasing successful graduates as examples of persistence, sponsoring social events and seminars, and to help students with work-life balance initiatives (Hill et al., 2010; Lichtenstein, Chen, Smith & Maldonado, 2013; Marra et al., 2009). The institutional culture is directly related to the extent to which the student becomes involved in campus activities, and that involvement is critical to retaining the student (Tinto, 1993).

STEM Retention Case Studies

A method of combating STEM retention issues at community colleges, and likewise engineering and engineering technology retention, is the approach of creating STEM hubs, or centers to serve as a "single destination for all academic, outreach, transfer and professional development opportunities" in STEM fields (Camacho, 2015, p. 3). Such centers can be created at the institutional level, or at the state and system-wide levels. STEM Centers bring together STEM services and opportunities to address obstacles community college students may face when pursuing a STEM credential, mainly a lack of awareness of academic options and low self-efficacy.

Strimel and Grubbs (2016) stated that "there is no doubt architects of technology and engineering education are confronted with a daunting task of adequately preparing for an evolving landscape" (p. 2). The North Carolina STEM Center, in a report on the future of STEM education in the state published in 2011, stated that because educational technologies are commonplace in today's higher education institutions, instructors of STEM-based courses, even those that rely heavily on lab-based hands-on instruction, must adapt to the changing trends of educational delivery (North Carolina Department of Public Instruction, 2011).

One of the challenges issued to community colleges by the NC STEM Center was to increase math competency by using lab-based instructional models and providing practical alternatives to the traditional algebra/calculus track seen in engineering (not engineering technology) concentrations (North Carolina Department of Public Instruction, 2011). The NC STEM Center also noted that community colleges work with local high schools in their service area to develop STEM-based summer bridge programs to ease the transition into college for graduating high school seniors.

The NC STEM Center challenged the NC Community College System to increase opportunities for entry level job training and degree attainment tied to industry certifications and licensure, providing both STEM program graduates, and those who did not complete a degree, the opportunity to leave with career ready credentials (North Carolina Department of Public Instruction, 2011)

On an institutional level, the STEM Center at Cañada College, a small but culturally diverse community college in Redwood City, CA (Camacho, 2015), presents an interesting case study in student retention. To tackle those issues of academic awareness and self-efficacy, the STEM Center deployed a multi-faceted approach. First, in an effort to tackle math intimidation among new enrollees, the college employed a model of supplemental instruction originally developed at the University of Missouri-Kansas City (UMKC).

Supplemental instruction is a method of supporting "at-risk classes," not students, in math, physics, and chemistry fields. Classroom instruction is supplemented by group tutoring sessions, led by students who have successfully completed the course, held weekly outside of class to provide a less intimidating environment for students to ask questions about the course material. An obstacle to implementing the UMKC model is that it proved difficult for college administrators to find students who could lead such programs because of the short window of time a student spends at a community college, compared to a university where a similar program may be led by the same students for multiple semesters.

Other approaches to increasing persistence by Cañada College's STEM center include the presence of a STEM-only counselor, whose academic support, university transfer, and career readiness services are tailored specifically to current and prospective students in STEM related majors, such as engineering technology (Camacho, 2015). Finally, the STEM Center exposes students to STEM career options by bringing in guest speakers who are employed of have achieved success in a STEM related field, an approach that has also been suggested by Piper and Krehbiel (2015). Guest speakers, preferably local in nature, are invited to discuss their path to employment, their educational experiences, and current projects (Camacho, 2015). Selection of guest speakers depends on three factors: being relevant to the demographics of the student population, share similar educational paths as community college students, and represent the diversity of STEM career options. Culturally relevant guest speakers have been shown to be effective in improving the self-efficacy of female STEM students (Hill, Corbett, & Rose, 2010).

Since the implementation of the STEM Center in 2009, coupled with the resulting STEM initiatives outlined above, the overall STEM enrollment increased 43% from 2008 to 2013, while engineering enrollment rose 126% over that time (Camacho, 2015). The gains in STEM enrollment occurred while Cañada College only saw a 5% rise in overall enrollment.

In addition to the approaches outlined by Camacho (2015), Piper, and Krehbiel (2015) suggested that offering career counseling and internship opportunities are ways that STEM programs can retain students to graduation. They also added that offering merit-based scholarships to high achievers in STEM fields in high school entices those with a predisposition for STEM to continue STEM based learning in college.

Another case study in tackling engineering technology enrollment is the South Carolina Advanced Technological Education (SC ATE) Center of Excellence. The SC ATE Center is a statewide initiative supported by the National Science Foundation and the South Carolina Technical College System to focus on increasing the "quality, quantity, and diversity of engineering technology graduates" by providing teaching materials, resources, and workshops (Wood & Craft, 2001, p. 6). In the years immediately after implementation, retention rates improved to greater than 75% for engineering technology programs in the participating schools, an improvement (Wood & Craft, 2001). Graduation rates were approximately 50% for students who enrolled in the pilot program, an improvement from the 10% average graduation rate in the engineering technology programs beforehand. Two years after the initial pilot program, female enrollment increased 15% and African-American enrollment increased 29%.

A key to the success of the SC ATE curriculum is that it is designed foremost with student retention in mind (Wood & Craft, 2001). The curriculum includes two components: the "technology gateway" (a pre-engineering technology program aimed at academically under-prepared students), and the "engineering technology core" (including courses introducing the fundamentals in areas such as electronic, drafting, and safety.). In addition, learning spaces are designed to replicate the workplace, and instruction techniques are modeled after industry management strategies. Industries in the state can buy-in to the process, both literally and figuratively, by sponsoring students through ATE Scholars partnerships. ATE Scholars are recruited and selected as a joint effort between the industry and the participating schools, and selected students receive tuition reimbursement as well as real-world work opportunities through paid internships.

To combat the very issue outlined by Strimel and Grubbs (2016) that some secondary and post-secondary educators lack the proper training for specialized STEM instruction, the SC ATE facilitates tours of industry facilities and job shadowing for faculty in the participating programs (Wood & Craft, 2001). This allows faculty to interact with industry leaders and get a first-hand perspective of industry needs. The SC ATE also promotes faculty workshops with a team-based focus to promote pedagogic collaboration amongst engineering technology faculty.

Chapter Summary

Science, technology, engineering, and mathematics programs have received considerable attention in recent years because of the national focus on student outcomes and workforce development in such fields (Strikwerda, 2018). Christie (2015) stated that engineering and engineering technology programs are cornerstones of STEM, but research into retention of both subsets is limited, and less than half of students who declare an engineering technology major will persist through the first year.

The focus on retention of STEM programs is underscored by the reality that the United States is losing its hold as a world superpower in STEM fields (Olson & Riordan, 2012). The United States has struggled to keep up with the rest of the world in supplying qualified and skilled workers in STEM fields (Sass, 2015). It has been stated that meeting goal of creating one million additional STEM graduates by 2022 could be easily achieved if retention rates for STEM related majors across all postsecondary levels were increased to at least 50% (Olson & Riordan, 2012). Boosting retention is the easiest and most cost-effective way of reaching the PCAST goal. Identifying the factors that influence retention of engineering and engineering technology programs will assist in developing meaningful admissions procedures and aid in advising of engineering and engineering technology students (Cole, High & Weinland, 2013; Fike & Fike, 2008).

CHAPTER 3

RESEARCH METHODOLOGY

This quantitative study identified commonalities among students who persist to graduation in community college engineering and engineering technology programs. Less than half of students who declare an engineering or engineering technology major persist through the first year (Chen & Soldner, 2013; Christie, 2015). Snyder and Cudney (2018) urged that more should be done to increase the retention and completion of community college STEM students.

Identifying factors common among retained students could potentially help community college engineering technology program faculty better understand why students persist in these programs and could also help tailor support to students who do not display traits that are indicative of persistence. Fike and Fike (2008) stated that understanding why students choose to leave or stay in higher education is essential for any faculty or administrator wanting to make a difference in the lives of their students. Therefore, predicting student retention with data may allow educators to intervene with students whose characteristics make them vulnerable to dropping out.

Research Questions and Null Hypotheses

This study was guided by the following research questions and corresponding null hypotheses:

1. Is the retention rate for community college engineering and engineering technology programs significantly different than the retention rate of other majors (computer and

information sciences, bio and physical science, sci-tech, math, agriculture, general studies and other, social sciences, humanities, healthcare, business, education, undeclared, and other)?

$H_0$1: The community college retention rate for engineering and engineering technology programs is not significantly different than that of other majors.

2. To what extent do academic variables (attendance pattern, high school GPA, highest level of high school mathematics, and college credits taken in high school) predict retention of community college engineering and engineering technology students?

$H_0$2: Academic variables do not have a significant relationship on retention of community college engineering and engineering technology students.

3. To what extent do financial variables (employment status, income group, total aid amount, and TRIO program eligibility) predict retention of community college engineering and engineering technology students?

$H_0$3: Financial variables do not have a significant relationship on retention of community college engineering and engineering technology students.

4. To what extent do student background variables (age, gender, dependency status, parent's highest education level, and travel time) predict retention of community college engineering and engineering technology students?

$H_0$4: Student background variables do not have a significant relationship on retention of community college engineering and engineering technology students.

5. To what extent does the combination of academic, financial, and student background variables predict retention of community college engineering and engineering technology students?

H_05: The combination of academic, financial, and social variables do not have a significant impact on the retention of community college engineering and engineering technology students.

Instrumentation

The instrument for the BPS:12/14 was based primarily from previous iterations of the BPS study along with new data elements identified since the last iteration of the BPS study. The instrument for the BPS is comprised of seven sections. In the first section, enrollment, respondents were questioned about their likelihood of completing a degree, the highest degree they expect to complete, and perceptions of their future occupations and earnings. Demographic information such as date of birth, marital status, and gender were identified in this section as well. In the second section, participants were questioned about their educational experiences at their most recent postsecondary institution including delivery method, academic and social integration, use of campus services, residence, and commute information (if applicable).

In the third section, participants were asked about their financial aid status, including information on grants, scholarships, veteran's benefits, and private loans. Respondents were also asked about the amount their total amount borrowed, their current monthly payments, and whether they have served as a work-study. In the fourth section, respondent's employment information from 2011-2014 was compiled including employer name, dates of employment, employment status while enrolled, average hours worked per week, and whether the student primarily considered themselves to be an employee or a student. More specific questions were asked about completers and non-completers most recent employer, dates of employment, occupation, professional licensure/certificates attained, earnings, benefits, whether they had looked for work while not working, and whether their most recent employment was related to their major and career path. In the fifth section, respondents were asked about their annual income, spouse's annual income (if applicable), number of children or dependents, whether family or friends had helped pay for their education or living experiences, whether they financially supported someone else monthly, credit card use, monthly residential expenses, and vehicle loan amount. Respondents were also asked about the receipt of untaxed benefits, parent's marital status and income, and college attendance of parents.

In the sixth section, respondents were asked for information pertaining to demographic background information such as demographic characteristics, citizenship status, race and ethnicity, military service, spouse and parent's highest level of education, disability status, and self-ratings of physical and mental health. Finally, the seventh section of survey questions dealt with location information, such as their address, so that respondents could be contacted for the follow up reports.

Population and Sample

The Beginning Postsecondary Students Longitudinal Study (BPS:12/14), conducted by the National Center for Education Statistics, is a 2014 follow-up study of students who entered postsecondary education in the 2011-2012 academic year. This is the most recent dataset available from the NCES that is applicable to this study, and the timeframe from the acquisition of the data by the NCES to the completion of this study is similar to other studies that using a BPS dataset (Hughes, 2016; Pao, 2016; Van Noy & Zeidenberg, 2014). The BPS:12/14 population are students who entered postsecondary education at any institution in the U.S. for the first time in the 2011-2012 academic year. The majority of the sample were selected based on eligibility for the 2011-2012 National Postsecondary Student Aid Study (NPSAS:12), though institutional data were used to identify students not eligible for the NPSAS:12 but were first-time beginning students, and thus eligible for the BPS:12/14.

The total sample for the BPS:12/14 consisted of 37,170 first-time beginning students. This sample included students who were eligible and completed the NPSAS:12, students who were eligible and did not respond to the NPSAS:12, and students who were first-time beginning students but not eligible for the NPSAS:12. Of the 37,170 students who were selected to participate in the BPS:12/14, 33,250 students were located and 24,770 responded. Of the respondents, 19,530 students completed the instrument by web while 5,240 completed via telephone.

Due to the BPS:12/14 using self-reported data on top of data from the NPSAS:12, the inability to locate NPSAS:12 participants as well as NPSAS:12 participants refusing to complete the BPS:12/14 survey produced non-response bias in the results. To compensate for this issue, NCES researchers used sample weighting to account for the non-response bias. The weights were calibrated based on the weighted estimates obtained from the NPSAS:12, the 2010-2011 IPEDS Fall Enrollment database, and the 2011-2012 IPEDS Student Financial Aid and Net Price database (Hill, Smith, Wilson, Wine, & Richards, 2016). The NCES researchers developed a base weight, called “WTA000” along variants of the base weight to account for non-response bias in the data from BPS:12/14 variables (Hill et al., 2016). PowerStats, the web-based program used to perform the majority of the statistical calculations in this study, selected a weight based on the variables the researcher chose for the given statistical analysis. In each case, PowerStats selected the base weight “WTA000.”

Data Collection

As stated previously, the BPS:12/14 instrument is based on prior BPS instruments and new items were developed since the previous iteration of the Beginning Postsecondary Students study (BPS:04/09). BPS:12/14 data were collected from interviews with participating students.

The instrument included seven sections: enrollment, education experiences, financial aid, employment, income and expenses, background, and locating. Participants could complete the survey over the phone or by internet, but the items were identical. Interviews by telephone were monitored to assure quality control.

Beyond surveying the participants, a portion of the BPS: 12/14 data were collected by matching study participants with their entries in administrative databases, including the Central Processing System (CPS), the National Student Loan Data System (NSLDS), and the National Student Clearinghouse (NSC). The CPS provided information from FAFSA forms, that was used to provide student information for the academic years after 2011-2012. The NSLDS provided data on the nature and amount of both Pell Grants and federal student loans. Finally, the NSC provided information on enrollment, degree, and certificate records on behalf of participating institutions. The matching of students from the sample to the three data bases was not one-to-one; the CPS provided information for approximately 50% of the sample per academic year, while the NSLDS provided information on 63% of the sample and the NSC provided information for 77% of the sample. In addition, ACT (28%) and SAT (26%) scores were matched.

Participant confidentiality was protected through the technique of data-swapping perturbation procedure. The swap rates were carried out under “specific, targeted, but undisclosed" swap rates (Hill et al., 2016). Some missing data were imputed using values "deduced with certainty based upon logical relationships among observed variables" (Hill et al., 2016). The weighted sequential hot deck method was used to replace missing data with plausible values from statistically selected donor cases. BPS staff reviewed the imputed data and resolved any anomalies as needed.

The researcher viewed the BPS:12/14 data through PowerStats, a statistical research web applet offered by the NCES DataLab via the NCES website. PowerStats provides limited access to a myriad of datasets produced by NCES postsecondary studies, including previous iterations of the BPS. Though the raw data generated by the individual BPS participants cannot be directly viewed through PowerStats, the descriptive statistics of the sample can be viewed. In addition to descriptive statistics, PowerStats allows users to perform basic statistical analysis on the NCES datasets, such as percentage distributions, linear regressions, logistic regressions, and correlations. The researcher created a free PowerStats account using his institutional email, and after verification, was granted access to the application.

Data Analysis

An ex-pos-facto non-experimental quantitative study was conducted to provide a more in-depth understanding of the retention of engineering and engineering technology students at U.S. community colleges. For Research Question 1, a chi-square test was conducted to compare the retention rate for engineering and engineering technology majors against the retention rate of all other majors combined. Other majors include undeclared, computer and information sciences, bio and physical science, sci-tech, math, agriculture, general studies and other, social sciences, humanities, healthcare, business, education, and other majors.

PowerStats, a statistical analysis tool developed for the NCES by RTI International, was used to run percentage distributions, logistic regressions, and provide descriptive statistics. PowerStats allows authenticated users access to a plethora of the NCES postsecondary datasets and provides tools for basic statistical calculations, such as regressions and correlations. For the purposes of this study, the BPS:12/14 was selected in PowerStats as the database from which all statistical calculations were completed. The data were analyzed at the .05 level of significance.

PowerStats does not include the chi-square test natively as part of its statistical operations; therefore, the chi-square test was conducted using the statistics software program SPSS. However, PowerStats was needed to provide the data for the chi-square test. Therefore, a percentage distribution table similar to that shown in Table 1 was generated to view the percentages of respondents who majored in a community college engineering or engineering technology program who were retained or not-retained, as well as the retention and non-retention for all other majors at the community college level.

The X^2 value is computed based on observed and expected values and is compared against a critical X^2 value (a value that depends on the degrees of freedom and the level of significance of the test) to determine if the result is either rare or common (Witte & Witte, 2010). The smaller the difference between the observed and expected values, the smaller the X^2 value, indicating that the outcome is common and the null hypothesis (no significant relationship between variables) should be retained. The larger the difference between the observed and expected values, the larger the X^2 value, indicating that the outcome is a rare occurrence and the null is rejected. In short, a X^2 value higher than the critical X^2 value rejects the null, while a value smaller than the critical value means the null is retained.

Also reported along with the X^2 value is Cramer's *V* and a p-value. Cramer's *V* is a rough estimate of the effect size. In general, the strength of the relationship between two variables is small if Cramer's *V* approximates .01 or lower, medium if it approximates .09, and large if it meets or exceeds .25 (Witte & Witte, 2010). The p-value is the probability and is tested at a 0.05 level of significance. A p-value less than .05 indicates a rare outcome, and thus the outcome is statistically significant, and a null-hypothesis of no significance is rejected (Hosmer & Lemeshow, 1989). A p-value greater than .05 indicates the outcome is common and therefore not significant, and a null-hypothesis of no significance is retained.

For Research Question 2, a logistic regression was used to examine the extent to which academic variables, a combination of attendance intensity, high school GPA, highest completed level of high school mathematics, and college credits taken in high school, predict retention of community college engineering and engineering technology students.

For Research Question 3, a logistic regression was used to examine the extent to which financial variables, a combination of employment status, income group, financial aid status, WIC status, and TRIO program eligibility, predict first-to-second year retention of community college engineering and engineering technology students? Research Question 4 was examined using a logistic regression to examine the extent to which social variables, a combination of age, gender, citizenship, marital status, dependency status, parent's education level, parent's marital status, first-generation status, urbanization of campus, commute time, and commute distance, predict first-to-second year retention of community college engineering and engineering technology students?

Finally, Research Question 5 was examined with logistic regression to determine the extent to which the combination of academic, financial, and social variables together predict retention of community college engineering and engineering technology students.

The logistic regression was used for Research Questions 2 through 5. The intent of logistic regression is similar to that of linear regression: to find the best fitting model to describe the relationship between an outcome and a set of predictor variables (Hosmer & Lemeshow, 1989). Instead of predicting a continuous output based on one or more predictor variables, as is the case in linear regression, a logistic regression is used to model a dichotomous variable with discrete, binary outcomes (Hilbe, 2016).

A logistic regression performed in PowerStats yields the following output data: regression model information, measures of fit report, hypothesis testing results, estimated full sample regression coefficients, odds ratio results, and correlation matrix.

The hypothesis testing results show the WaldF, and the ProbabilityF statistics. WaldF is the Wald statistic, which is the ratio of the estimated coefficient to the standard error estimate for the predictor variables (Hosmer & Lemeshow, 1989). The Wald statistic is used to obtain an approximation of the significance of the predictor variables. A high Wald score indicates the regression coefficient, and therefore the predictor variable, has a strong impact on the overall prediction (Chatterjee & Simonoff, 2013). The Probability F, or p-value, column from the hypothesis testing results is notable because shows probability of the overall model. Each variable, as well as the overall fit of the model, is tested at a 0.05 level of significance. Values less than the level of significance indicate that the variable is statistically significant to the predictor model.

The measures of fit report showed the -2 log likelihood, a Cox-Snell likelihood ratio, and an Estrella likelihood ratio of the predictor model. Likelihood ratios "compare the observed values of the response variable to predicted values obtained from models with and without the variable in question" (Hosmer, 1989, p. 13). The -2 log likelihood value is obtained by multiplying the log likelihoods for the constant only model and the model containing the predictor variable by negative two. A -2 log likelihood value approaching zero indicate a strong fit for the prediction model (Osborne, 2015). Both the Cox-Snell and Estrella likelihood ratios yields a value between 0 and 1, with a result closer to 1 indicating a stronger fit for the predictor model (Chatterjee & Simonoff, 2013).

The estimated full sample regression coefficients include the following entries: Standard Beta coefficient (Std. β), the Standard Error (S.E.), and a p-value. The standard beta coefficient is indicative of the strength of the predictor variable on the overall prediction of retention (Osborne, 2015). A standard beta coefficient that is positive indicates that the respondents in such categories have an increased probability of retention over the reference group, while a negative value indicates a decrease in the probability of retention. The standard error describes the accuracy of the estimate of the coefficient and allows the researcher to determine if the coefficient is significantly different than zero (Hilbe, 2016). The p-value is the probability of obtaining a coefficient at least as great as the observed coefficient with $\beta = 0$ and is tested at a 0.05 level of significance (Hilbe, 2016).

Finally, PowerStats generates an odds ratio results table that included the odds ratio and confidence intervals for the predictor variables, in addition to b-, t-, and p-values for the predictor variables. The odds ratio is the ratio of the odds for x = 1 to the odds for x = 0, or simply the odds of one of the binary outcomes occurring divided by the probability of the other outcome occurring (Hosmer & Lemeshow, 1989). Therefore, for the purposes of this study, it is the probability of retention divided by the probability of non-retention. An odds ratio greater than one indicates that as the predictor variable increases in value, the student is more likely to be retained, while a odds ratio less than one indicates that the student is less likely to be retained as the predictor variable value increases. The 95% odds ratio confidence intervals (upper and lower) are "exponentiations of the coefficient confidence intervals" and indicate that the odds ratio will fall between the upper and lower limits 95% of the time (Hilbe, 2016, p. 24). If the predictor variable displays a significant p-value, then the resulting odds ratio confidence interval must not include zero within the interval.

Chapter Summary

A non-experiential, ex post facto quantitative study was developed to examine the impact of academic, financial, and social factors on retention of community college engineering and engineering technology students. Research Question 1 will be tested with a chi-square test, while Research Question 2 will be examined with descriptive statistics. Research Questions 3 through 6 will be examined using logistic regressions. To complete the statistical calculation of the dataset, a web-based statistical tool provided by the NCES (PowerStats) was used. This study was an examination of the factors contributing to engineering and engineering technology student retention at U.S. community colleges.

CHAPTER 4

DATA ANALYSIS AND RESULTS

The purpose of this study was to examine the academic, financial, and student background factors influencing the first-to-second year retention of engineering and engineering technology students at community colleges. An ex-pos-facto non-experimental quantitative study was conducted to provide a more in-depth understanding of the retention patterns of this subset of the community college student population.

Chapter 4 presents an overview of the retention patterns of key demographics of the community college engineering and engineering technology student population, followed by analysis of the five research questions featured in this study. A chi-square test was conducted to evaluate the first research question, while a logistic regression was used to analyze the remaining four research questions.

Dependent Variables

The variable attainment and enrollment 2012-2013 (PRATY2) was used as the dependent variable in each of the five research questions in this study. With BPS:12/14 respondents having enrolled in postsecondary education for the first time in the 2011-2012 academic year, this variable identified the respondent's attainment and enrollment by the completion of the student’s second academic year in postsecondary education, or the 2012-2013 academic year. Variable categories included: attained degree during academic year, no degree (enrolled at least 8 months), no degree (enrolled less than 8 months), and no degree (did not enroll). For the purposes of this study, the variables attained degree during academic year, no degree (enrolled at least 8 months), and no degree (enrolled less than 8 months) were combined into a new category called "retained," while the variable no degree (did not enroll) alone was simply renamed as "not-retained" for better uniformity. The new groupings were used consistently throughout the five research questions and the reporting of demographic data.

Not only did the decision to group certain categories together serve to produce a binary output from the dependent variable, a necessity for logistic regression, but it also aligned with retention rate as defined in Chapter 1. The grouping of the categories attained degree during academic year, no degree (enrolled at least 8 months), and no degree (enrolled less than 8 months) meant that if a student enrolled at any point in the 2012-2013 academic year, or their second year in postsecondary education, then the student was classified as being retained. If the student did not enroll at all during the 2012-2013 academic year, then the student was classified as not retained.

Predictor Variables

The availability of data played an important role in the selection of predictor variables for this study. The researcher desired to include several academic, financial, and student background variables as predictors. However, the relatively low sample population of the community college level engineering and engineering technology subset in the NPSAS:12 combined with a less than 100% response rate for the BPS:12/14 follow up survey meant that certain key variables did not have enough data to produce usable statistical results.

If the sample size for a variable or variable subcategory is low enough to where the standard error represents at least 30% of the sample, PowerStats will display a warning to interpret the results of statistical analyses with caution. Yet another warning will be displayed if the standard error represents at least 50% of the sample size. Furthermore, PowerStats displays an error message if the sample size for a particular variable or variable subcategory does not meet reporting standards. PowerStats indicated that the following academic, financial, and student background variables had a workable sample size, had large enough sample sizes to meet reporting standards, but some variable subcategories did experience warnings in the output as noted.

Academic Predictor Variables

Academic predictor variables chosen for this study included: attendance pattern, high school GPA, highest completed level of high school mathematics, and college credits taken in high school. All the academic predictor variables produced data that were categorical in nature.

Attendance pattern (ATTNPTRN) is the student's attendance at all institutions attended in the 2011-2012 academic year. Variable categories included exclusively full-time, exclusively part-time, and mixed full-time and part-time enrollment. As is the case of all variables used in this study that pertain to the 2011-2012 academic year (the respondents' first year in postsecondary education), the data from the student's first academic year is used as a predictor for the enrollment in the 2012-2013 academic year (the respondents' second academic year).

Grade point average in high school (HSGPA) is a self-reported variable with categories ranging from 0.5-0.9 (*D- to D*) to 3.5-4.0 (*A- to A*). Due to the low number of responses for high school GPA's less than 2.0, the researcher combined all responses below this number into a single category. For high school GPA scores of 2.0 or greater, the researcher kept the default half point increments to categorize the data.

The variable highest level of high school mathematics (HCMATHHI) is a self-reported variable that indicates the highest level of math completed. Variable categories included: less than algebra 2, algebra 2, trigonometry, pre-calculus, and calculus and beyond. The researcher combined the algebra 2 and trigonometry categories due to low number of those completing trigonometry-only classes, and the grouping was a natural fit given their relative proximity in the high school math education hierarchy (Goel & Elstak, 2015).

Finally, the college credits taken in high school (HSCRDCOL) variable indicates whether the student took postsecondary level courses while in high school, with the exception of advanced placement and international baccalaureate courses. Respondents were limited to yes/no responses only.

Financial Predictor Variables

Financial predictor variables used in this study included: employment status, income group, total aid amount, and TRIO program eligibility criteria. All of the financial predictor variables produced data that were categorical in nature, with the exception of the continuous variable total aid amount.

Employment status (JOBFT12) indicates the employment pattern (no job, part-time, and full-time) of the respondent while enrolled in the 2011-2012 academic year. Income group (INCGRP) indicates the respondent's income level (low, low middle, high middle, and high) in the 2012 calendar year. Total aid amount (TOTAID) is the financial aid received during the 2011-2012 academic year. As noted, this variable yielded continuous data with responses ranging from $0 to approximately $123,700.

Finally, TRIO program eligibility criteria (TRIO) indicates the financial and first-generation status of the respondent during the 2011-2012 academic year. Variable categories included: low income and first generation; low income and not first generation; first generation and not low income; and not low income and not first generation.

Student Background Predictor Variables

Student background predictor variables included age, gender, dependency status, parent's highest education level, and the travel time to institution. Most of the predictor variables produced data that were categorical in nature, except for the continuous variables age and travel time to institution.

Age (AGE) was the respondents' age as of December 31, 2011 and produced continuous data ranging from ages 15 to 75, with an average age of 20.83 years. Gender (GENDER), an indication of the student's sex in the 2011-2012 academic year. Dependency status (DEPEND) during the 2011-2012 academic year produced two outputs, dependent and independent.

Parent's highest level of education (PAREDUC) is the highest level attained by either parent of the student as of the 2011-2012 academic year. Variable categories included: did not complete high school, high school diploma or equivalent, some college but no degree, associate degree/technical training, bachelor's degree, and graduate degree.

Finally, travel time to institution (TRLNPAVT) was the duration of the commute from residence to the students' first postsecondary institution attended during the 2011-2012 academic year. This was a continuous variable that produced data ranging from 1 minute per day to 180 minutes per day, with an average of just under 30 minutes of daily commute time.

Demographics of the Sample

Of the roughly 1775 students in the BPS:12/14 who entered postsecondary education for the first time in the 2011-2012 academic year and attended a community college as their first postsecondary institution, the engineering and engineering technology subset accounted for approximately 98 students, or 6% of the overall sample. Of the weighted sample of engineering and engineering technology students, approximately 53% who enrolled for the first time in the 2011-2012 academic year enrolled again at some point in the following academic year, while approximately 47% did not return.

With regards to age, approximately 78% of the engineering and engineering technology students included in this study were under the age of 24. Only 14% were in their late 20’s, and roughly 8% were older than 30. Approximately 76% of students age 18 and younger were retained to the second year, with the retention rate decreasing down to 50% for students age 24-29. Conversely, students in their 30’s were retained at a relatively high rate (approximately 93%).

A disparity exists between male and female retention in engineering and engineering technology programs. Approximately 68% of males and 48% of females were retained from first to second year. However, PowerStats indicated the number of female community college engineering and engineering technology students was low enough (approximately 6% of the sample) that the results should be interpreted with caution due to the standard error representing more than 50% of the sample.

A similar problem was observed when determining the retention patterns of different racial categories. When using the variable race/ethnicity census categories with its basic race groupings, only the white, African-American, and Latino categories had enough data to meet PowerStats reporting standards for a percentage distribution, and all other racial categories produced errors in the output. Instead, the groupings were changed to exclusively white and non-white students. White students (72.3%) and non-white students (65.5%) were retained at relatively high rates, and PowerStats gave no indication that the results should be interpreted with caution due to low sample size. Table 1 shows the retention rates and number of responses for community college engineering and engineering technology students based on age, gender and race.

Table 1

Percentage Distribution and Weighted Number of Responses for Age, Gender, and Race of Community College Engineering and Engineering Technology Students

	Retained	Not-Retained	
Variable	%	%	N
Age			
18 or younger	75.6	24.4	35.5
19-23	68.2	31.8	41
24-29	49.7	50.3	13.2
30-39	92.9	7.1[a]	4.8
40 or older	‡	‡	3.5

Table 1 (Continued)

Variable	Retained %	Not-Retained %	N
Gender			
Male	67.6	32.4	91.8
Female	47.3	52.7	6.3
Race			
White	70.8	29.2	67
Non-White	65.9	34.1	31.1

[s] Per NCES standards, the standard error represents more than 50 percent of the estimate and the result must be interpreted with caution. ‡ indicates reporting standards were not met.

Research Question #1

RQ1: Is the retention rate for community college engineering and engineering technology programs significantly different than the retention rate of other majors?

$H_0$1: The community college retention rate for engineering and engineering technology programs is not significantly different than that of other majors.

To scrutinize the difference in retention rate between the two groups, a chi-square test was chosen to compare the retention for engineering and engineering technology majors against all other majors combined. To ensure that respondents from non-community college institutions were not included in the comparison of retention, the data were limited to only to respondents who enrolled at a two-year institution in the 2011-2012 academic year using filtering capabilities within PowerStats.

As stated previously, PowerStats does not include the chi-square test natively as part of its statistical operations. Therefore, the chi-square test was conducted using the statistics software program IBM SPSS 25. However, PowerStats was needed to generate the data for the chi-square test. To generate the percentage distribution table, the variable attainment and enrollment during 2012-2013 was selected as the column variable. This variable identified the respondent's persistence and attainment at any institution by the completion of the student's second academic year in postsecondary education.

The variable field of study: undergraduate (10 categories) 2011-2012 was selected for both of the rows of the percentage distribution table in PowerStats. This variable indicated the student's declared field of study in their first academic year and was divided into ten default categories. For the first row of the distribution, the engineering and engineering technology category was selected. Therefore, only the retention of respondents who declared an engineering or engineering technology major in the 2011-2012 academic year would be displayed in the first row of the table. In the second row, the other nine categories listed in the field of study: undergraduate (10 categories) 2011-12 variable were grouped together and called simply non-engineering and engineering technology majors. These included: computer and information sciences, bio and physical science, sci-tech, math, agriculture, general studies, social sciences, humanities, health care, business, education, other, and undeclared. This grouping of the other nine major categories was called simply non-engineering technology majors.

The resulting percentage distribution table from PowerStats is shown in Table 2. This table shows the first-to-second year retention rate for first-time postsecondary education enrollees in the 2011-2012 academic year for both the engineering and engineering technology majors and all other majors combined. PowerStats also produced weighted sample population for each row of the table (i.e. the total number of engineering and engineering technology majors) as part of the distribution table output. This allowed the researcher to calculate the total number of weighted respondents, a value needed to conduct a chi-square test, for each cell based on the percentage located in the cell. Table 3 shows the calculated totals based on the percentage distributions displayed in Table 2.

Table 2

Percentage Distribution of the Retention of Engineering and Engineering Technology Students and the Retention of the Overall Community College Student Population

	Retained		Not-Retained		
Major	%	N	%	N	Total
Engineering and Engineering Technology Majors	52.9	51.8	47.1	46.2	98.0
Non-Engineering and Engineering Technology Majors	52.7	883.7	47.3	793.1	1676.8
Total		935.5		839.3	1774.8

After the total number of respondents in each cell were known, a chi-square test was performed to examine the relationship of the retention of engineering and engineering technology majors to the retention of all other majors at the community college level. As mentioned earlier, PowerStats does not natively support chi-square tests as part of its statistical tools. Therefore, the test was conducted using IBM SPSS 25. The relationship between the retention rate of community college engineering and engineering technology majors to the retention of the overall community college population was not significant $X^2(1, N = 1774.8) =$

0.004, p = .947, ns, Cramer's *V* = 0.002). The X^2 value of 0.004 is less than the critical value of 3.84, which is determined by 1 degree of freedom and a 0.05 level of significance (Witte & Witte, 2010).

Based on the results of the chi-square test, the null hypothesis is retained. Community college engineering and engineering technology students are not retained at a significantly different rate than that of the overall community college student population. In fact, the results of the chi-square test show that the first-to-second year retention pattern of community college engineering and engineering technology students was nearly identical to that of the overall community college population for first-time college attendees in the 2011-2012 academic year.

Research Question #2

RQ2: To what extent do academic variables predict retention of community college engineering and engineering technology students?

$H_0$2: Academic variables do not have a significant relationship on retention of community college engineering and engineering technology students.

A logistic regression analysis was conducted to evaluate the extent that academic variables predict retention of community college engineering and engineering technology students. The dependent variable for this logistic regression was attainment and enrollment during 2012-2013. Because this study pertains to associate degree seeking students only, results were filtered to show data from only respondents who enrolled in two-year institutions. In addition, the results were filtered by program of study to include only engineering and engineering technology students in the output. The independent (predictor) variables included attendance pattern, high school GPA, highest completed level of high school mathematics, and college credits taken in high school. All the predictor variables produced data that is categorical in nature.

The following reference groups were selected for both the dependent and independent variables. For the dependent variable, attainment and enrollment during 2012-2013, the reference selected were students who were not-retained. For independent variables, the reference was students who were (a) attended full-time, (b) had a 3.5-4.0 high school GPA, (c) completed calculus or beyond in high school, and (d) took some college credits in high school.

Based on the log likelihood scores shown in Table 3, the multi-variable prediction model (-53841.403) was a better fit than the intercept-only model (-62215.055). This was confirmed by the hypothesis testing results from Table 4 and the odds ratio results from Table 6 which showed that the predictor model had a p-value of 0.059, while the intercept-only model had a p-value of 0.253. Thus, the predictor model was a better fit than the intercept-only model.

Table 3

Measures of Fit Report for Research Question 2

Measure of Fit	
-2 log-likelihood	0.135
Log likelihood, intercept-only model	-62215.055
Log likelihood, full model	-53841.403
Likelihood ratio (Cox-Snell)	0.170
Likelihood ratio (Estrella)	0.181

Table 4

Hypothesis Testing Results for Research Question 2

Predictor	WaldF	Num. DF	Denom. DF	Probability F
Overall Fit	1.822	10	191	0.059
Attendance pattern	6.205	2	199	0.002
High school GPA	1.067	4	197	0.374
Highest level of high school mathematics	0.325	3	198	0.807
College credits taken in high school	1.092	1	200	0.297

The Estimated Full Sample Regression Coefficients for Research Question 2 in Table 5 shows the standard beta weights for the academic predictor variables. The strength of the predictor variable on the overall prediction of retention of community college engineering and engineering technology students is indicated by the variable's standard beta value. The variable category with the strongest positive impact on the prediction of retention was took college-level courses while in high school (0.100). The only other variable with a category that had a positive impact on the prediction was a mixed (part-time and full-time) attendance pattern (0.007). All other variable categories had a negative standard beta value, and the variables with the strongest negative impact on the prediction of retention was exclusively part-time attendance pattern (-0.323) and a high school GPA of 2.0-2.4 (-0.210).

Table 5

Estimated Full Sample Regression Coefficients for Research Question 2

Predictor	Std. β	S. E.	*t*-value	*p*-value
Attendance pattern				
Exclusively part-time	-0.323	0.090	-3.498	0.001
Mixed full- and part-time	0.007	0.070	0.108	0.914
High school GPA				
2.0-2.4 (C to B-)	-0.210	0.130	-1.571	0.118
2.5-2.9 (B- to B)	-0.080	0.100	-0.813	0.417
3.0-3.4 (B to A-)	-0.023	0.130	-0.179	0.858
Less than 2.0	-0.026	0.070	-0.389	0.698
Highest level of high school mathematics				
Less than algebra 2	-0.048	0.150	-0.327	0.744
Algebra 2/Trigonometry	-0.013	0.100	-0.121	0.904
Pre-calculus	-0.074	0.090	-0.825	0.410
College credits taken in high school				
No	0.100	0.090	1.109	0.269

Table 6 shows the odds ratio results for the logistic regression. The odds ratios indicated that students attending on a part-time basis were approximately 76% less likely to be retained than those attending full-time. However, students with a mixed attendance pattern were 6% more likely to be retained than those who attended exclusively full time. In addition, all high school GPA categories had a lower likelihood of being retained than the reference

(3.5-4.0 GPA), and all categories for the highest level of high school mathematics had lower odds of retention than the reference (completing calculus or above). Finally, those who did not take college-level courses in high school were nearly 82% more likely to be retained than those who did.

Given the p-value of the predictor variable model from Table 4 (p = .059), the null hypothesis is retained. The grouping of academic variables does not have a significant impact on the retention of engineering and engineering technology students at the community college level. Based on the p-values in Table 6, only the attendance pattern variable had any categories that showed statistical significance towards to the retention model. An exclusively part-time attendance pattern was statistically significant (p = .001), and given the odds ratio score of 0.238, it can be said that part-time attendance has a significantly negative impact on community college engineering and engineering student retention.

Table 6

Odds Ratio Results for Research Question 2

Predictor	Odds Ratio	Lower 95%	Upper 95%	*t*-value	*p*-value	*b*-value
Intercept	2.318	0.546	9.837	1.147	0.253	0.841
Attendance pattern						
Exclusively part-time	0.238	0.102	0.557	-3.332	0.001	-1.436
High school GPA						
2.0-2.4 (C to B-)	0.348	0.080	1.519	-1.412	0.160	-1.055
2.5-2.9 (B- to B)	0.580	0.142	2.366	-0.764	0.446	-0.545

Table 6 (Continued)

Predictor	Odds Ratio	Lower 95%	Upper 95%	*t*-value	*p*-value	*b*-value
High school GPA						
3.0-3.4 (B to A-)	0.881	0.212	3.661	-0.176	0.861	-0.127
Less than 2.0	0.742	0.128	4.286	-0.336	0.738	-0.299
Highest level of high school mathematics						
Less than algebra 2	0.753	0.139	4.093	-0.331	0.741	-0.284
Algebra 2/Trigonometry	0.945	0.336	2.658	-0.108	0.914	-0.057
Pre-calculus	0.642	0.208	1.987	-0.774	0.440	-0.443
College credits taken in high school						
No	1.816	0.589	5.604	1.045	0.297	0.597

Research Question #3

RQ3: To what extent do financial variables predict retention of community college engineering and engineering technology students?

$H_0$3: Financial variables do not have a significant relationship on retention of community college engineering and engineering technology students.

A logistic regression analysis was conducted to evaluate the extent that financial variables predict retention of community college engineering and engineering technology students. The financial predictor variables included employment status, income group, total aid amount, and TRIO program eligibility criteria. All of the predictor variables produced data that were categorical in nature, with the exception of the continuous variable total aid amount.

The following reference groups were selected for both the dependent and independent variables. For the dependent variable, attainment and enrollment during 2012-2013. The reference selected were students who were not-retained. For independent variables, the reference was students who were (a) not employed (employment status), (b) high income, (income group) and (c) not low income and not a first-generation college student (TRIO program eligibility). This is indicative of a dependent student who is a recent high school graduate who depends on their parents for financial support. The total aid amount variable did not have a reference group because it was a continuous variable.

The log likelihood scores in Table 7 show that the multi-variable prediction model (-62988.972) was a better fit than the intercept-only model (-67780.719). This finding was confirmed by the p-values found in the hypothesis testing results (Table 8) and the odds ratio results (Table 10) which showed that the predictor model had a p-value of 0.027 while the intercept-only model had a p-value of 0.705. Thus, the predictor model was a better fit than the intercept-only model, with the predictor model displaying statistical significance to retention of community college engineering and engineering technology students

Given the p-value of the predictor variable model ($p = .027$) from Table 8, the null hypothesis is rejected. The grouping of financial variables does have a significant impact on the retention of engineering and engineering technology students at the community college level.

Table 7

Measures of Fit Report for Research Question 3

Measure of Fit	
-2 log-likelihood	0.071
Log likelihood, intercept-only model	-67780.719
Log likelihood, full model	-62988.972
Likelihood ratio (Cox-Snell)	0.093
Likelihood ratio (Estrella)	0.096

Table 8

Hypothesis Testing Results for Research Question 3

Predictor	WaldF	Num. DF	Denom. DF	Probability F
Overall Fit	2.158	9	192	0.027
Employment status	1.255	2	199	0.287
Income group	0.403	3	198	0.751
Total aid amount	3.957	1	200	0.048
TRIO program eligibility criteria	1.684	3	198	0.172

Table 9 shows the standard beta weights for the academic predictor variables. The variables with the strongest positive impact on the prediction of retention of community college engineering and engineering technology students was the total aid amount (0.169), followed by the low-middle income group (0.135) and the high-middle income group (0.100). The variables with the strongest negative impact on the prediction of retention were low income and first-generation TRIO program eligibility criteria (-0.227), followed by first generation and not low-income status (-0.178) and working full-time while enrolled (-0.134).

Table 9

Estimated Full Sample Regression Coefficients for Research Question 3

Predictor	Std. β	S.E.	*t*-value	*p*-value
Employment status				
Part-time	0.058	0.110	0.551	0.583
Full-time	-0.134	0.100	-1.337	0.183
Income group				
Low	0.073	0.160	0.443	0.658
Low middle	0.135	0.120	1.133	0.259
High middle	0.100	0.130	0.748	0.456
Total aid amount	0.170	0.070	2.428	0.016
TRIO program eligibility criteria				
Low income and first generation	-0.227	0.110	-2.074	0.039
Low income and not first generation	-0.119	0.140	-0.859	0.392
First generation and not low income	-0.178	0.100	-1.705	0.090

Table 10 shows the odds ratio results for the logistic regression. The odds ratio results indicated that students working part-time while enrolled were 35% more likely to be retained that students who are not employed while enrolled. Conversely, students working full-time were approximately half as likely to be retained as those not working while enrolled. For the income group variable, low (approximately 37%), low-middle (approximately (83%), and high-middle groups (approximately 57.6%) were all more likely to be retained than the reference group. Finally, all categories for the TRIO program eligibility criteria variable were between approximately 60 to 70% less likely to be retained than the reference.

Because the total aid amount is a continuous variable, no comparisons to a reference group could be made in the odds ratio results. However, total aid amount was a statistically significant variable to the prediction model (p = .048). The only other variable having a statistically significant impact on the prediction was the TRIO program eligibility criteria, specifically low income and first-generation status (p = .038).

Table 10

Odds Ratio Results for Research Question 3

Predictor	Odds Ratio	Lower 95%	Upper 95%	*t*-value	*p*-value	*b*-value
Intercept	1.339	0.293	6.115	0.379	0.705	0.292
Employment status						
Part-time	1.350	0.446	4.089	0.534	0.594	0.300
Full-time	0.495	0.159	1.545	-1.218	0.225	-0.703
Income group						
Low	1.371	0.262	7.168	0.376	0.707	0.316
Low middle	1.829	0.534	6.270	0.967	0.335	0.604
High middle	1.577	0.404	6.150	0.659	0.510	0.455

Table 10 (Continued)

Predictor	Odds Ratio	Lower 95%	Upper 95%	t-value	p-value	b-value
Total aid amount	1.000	1.000	1.000	1.989	0.048	0.000
TRIO program eligibility criteria						
Low income and first generation	0.329	0.115	0.942	-2.084	0.038	-1.112
Low income and not first generation	0.409	0.057	2.928	-0.896	0.371	-0.894
First generation and not low income	0.419	0.148	1.185	-1.650	0.101	-0.869

Research Question #4

RQ 4: To what extent do student background variables predict retention of community college engineering and engineering technology students?

$H_0$4: Student background variables do not have a significant relationship on retention of community college engineering and engineering technology students.

A logistic regression analysis was conducted to evaluate the extent that student background variables predict retention of community college engineering and engineering technology students. The dependent variable for this logistic regression was again attainment and enrollment during 2012-2013. The student background predictor variables included age, gender, dependency status, parents' highest education level, and the travel time. All the predictor variables produced data that were categorical in nature, with the exception of the continuous variables age and travel time.

For the dependent variable, attainment and enrollment during 2012-2013, the reference group selected were students who were not-retained. For independent variables, the reference was students who were (a) male, (b) dependent, and (c) had at least one parent with a graduate degree. The variables age and travel time from residence to the student's first postsecondary institution in 2011-2012 variable did not have a reference group because it was a continuous variable.

The log likelihood scores in Table 11 show that the multi-variable prediction model (-53953.288) was a better fit than the intercept-only model (-57891.345). This finding was confirmed by the p-values found in the hypothesis testing results (Table 12) and the odds ratio results (Table 14) which showed that the predictor model had a p-value of 0.236 while the intercept-only model had a p-value of 0.923. Thus, the predictor model was a better fit than the intercept-only model.

Table 11

Measures of Fit Report for Research Question 4

Measure of Fit	
-2 log-likelihood	0.0680
Log likelihood, intercept-only model	-57891.345
Log likelihood, full model	-53953.288
Likelihood ratio (Cox-Snell)	0.090
Likelihood ratio (Estrella)	0.093

Given the p-value overall fit of the predictor variable model (p = .236) in Table 12, the null hypothesis is retained. The grouping of student background variables does not have a significant relationship on the retention of engineering and engineering technology students at the community college level.

Table 12

Hypothesis Testing Results for Research Question 4

Predictor	WaldF	Num. DF	Denom. DF	Probability F
Overall Fit	1.307	9	192	0.236
Age	1.180	1	200	0.279
Gender	0.075	1	200	0.784
Dependency status	4.057	1	200	0.045
Parents' highest education level	0.355	5	196	0.879
Travel time	2.9908	1	200	0.0853

Table 13 shows the standard beta weights for the academic predictor variables. The variables with the strongest positive impact on the prediction of retention of community college engineering and engineering technology students were age (0.162) and attaining a bachelor's degree as the parent's highest level of education (0.039). These were the only two variables that had positive standard beta values. The variables with the strongest negative impact on the prediction of retention was dependency status: independent (-0.300), followed by travel time (-0.170) and high school diploma or equivalent for parent's highest level of education (-0.114).

Table 13

Estimated Full Sample Regression Coefficients for Research Question 4

Predictor	Std. β	S.E.	*t*-value	*p*-value
Intercept				
Age	0.162	0.130	1.207	0.229
Gender				
Female	-0.030	0.100	-0.301	0.764
Dependency status				
Independent student	-0.300	0.150	-2.048	0.042
Parents' highest education level				
Did not complete high school	-0.074	0.170	-0.440	0.661
High school diploma or equivalent	-0.114	0.170	-0.666	0.506
Some college but no degree	-0.067	0.190	-0.361	0.719
Associate's degree/technical training	-0.046	0.140	-0.334	0.739
Bachelor's degree	0.039	0.180	0.214	0.831
Travel time	-0.170	0.090	-1.866	0.064

Table 14 shows the odds ratio results for the logistic regression. The odds ratio results indicated that female students were approximately 22% less likely to be retained than male students, while independent students were almost 75% less likely to be retained than dependent students. Students with a parent who did not attain a graduate degree were generally less likely to be retained than the reference. The lone exception were students who had at least one parent attain a bachelor's degree, who were approximately 24% more likely to be retained than the reference.

Because both age and travel time are continuous variables, no comparisons to a reference group could be made in the odds ratio results. Neither of those variables had a significant p-value. The only variable category having a statistically significant impact on the prediction was the independent dependency status (p = .045).

Table 14

Odds Ratio Results for Research Question 4

Predictor	Odds Ratio	Lower 95%	Upper 95%	*t*-value	*p*-value	*b*-value
Intercept	1.223	0.020	75.066	0.097	0.923	0.201
Age	1.058	0.955	1.172	1.086	0.279	0.056
Gender						
Female	0.786	0.140	4.425	-0.274	0.784	-0.240
Dependency status						
Independent student	0.268	0.074	0.973	-2.014	0.045	-1.319
Parents' highest education level						
Did not complete high school	0.612	0.015	25.281	-0.260	0.795	-0.491
Some college but no degree	0.666	0.014	32.345	-0.207	0.836	-0.407
Associate's degree/technical training	0.736	0.020	27.491	-0.167	0.868	-0.306
Bachelor's degree	1.238	0.036	42.950	0.119	0.906	0.213
Travel time	0.983	0.964	1.002	-1.729	0.085	-0.017

Given the p-value overall fit of the predictor variable model ($p = .236$), the null hypothesis is retained. The grouping of student background variables does not have a significant relationship on the retention of engineering and engineering technology students at the community college level.

<u>Research Question #5</u>

RQ5: To what extent does the combination of academic, financial, and student background variables predict retention of community college engineering and engineering technology students?

$H_0 5$: The combination of academic, financial, and social variables do not have a significant impact on the retention of community college engineering and engineering technology students.

A logistic regression analysis was conducted to evaluate the extent that the combination of academic, financial, and student background variables predict retention of community college engineering and engineering technology students. The dependent variable for this logistic regression was attainment and enrollment during 2012-2013.

The predictor variables for this regression were the academic, financial, and student background variables that were statistically significant from the logistic regression results in Research Questions 2, 3, and 4. These variables were: attendance pattern (Research Question 2), total aid amount and TRIO program eligibility criteria (Research Question 3), and dependency status (Research Question 4). All the predictor variables produce data that were categorical in nature, except for the continuous variable total aid amount, and the variable categories and groupings remained unchanged from the prior regressions.

The following reference groups were selected for both the dependent and independent variables. For the dependent variable, the reference selected were students who were not-retained. For independent variables, the reference was students who were (a) enrolled full-time, (b) not low income and not a first-generation college student, and (c) dependent. This is indicative of a dependent student who is a recent high school graduate and depends on their parents for financial support. The total aid amount variable did not have a reference group because it was a continuous variable.

The log likelihood scores in Table 15 show that the multi-variable prediction model (-61881.12) was a better fit than the intercept-only model (-67780.719). This finding was confirmed by the p-values found in the hypothesis testing results (Table 16) and the odds ratio results (Table 18) which showed that the predictor model had a p-value of 0.026 while the intercept-only model had a p-value of 0.052. Thus, the predictor model was a better fit than the intercept-only model.

Table 15

Measures of Fit Report for Research Question 5

Measure of Fit	
-2 log-likelihood	0.0870
Log likelihood, intercept-only model	-67780.719
Log likelihood, full model	-61881.120
Likelihood ratio (Cox-Snell)	0.113
Likelihood ratio (Estrella)	0.118

Given the p-value overall fit of the predictor variable model (p = .026), the null hypothesis is rejected. Though the groupings of academic and student background variables individually did not have a significant relationship on the retention of community college engineering and engineering technology students, the overall combination of significant academic, financial, and student background variables included in this study do have a significant impact on predicting retention.

Table 16

Hypothesis Testing Results for Research Question 5

Predictor	WaldF	Num. DF	Denom. DF	Probability F
Overall Fit	2.342	7	194	0.026
Attendance pattern	3.289	2	199	0.039
Total aid amount	1.673	1	200	0.197
TRIO program eligibility criteria	0.853	3	198	0.467
Dependency status	1.227	1	200	0.269

Table 17 shows the standard beta weights for the academic predictor variables. The variable with the strongest positive impact on the prediction of retention of community college engineering and engineering technology students was the total aid amount (0.107), followed by mixed full-time and part-time attendance pattern (0.054). These were the only two variables that had positive standard beta values. The variables with the strongest negative impact on the prediction of retention was exclusively part-time attendance pattern (-0.212), followed by low income and first-generation TRIO program eligibility criteria (-0.136), and first generation and not low-income status (-0.118).

Table 17

Estimated Full Sample Regression Coefficients for Research Question 5

Predictor	Std. β	S.E.	*t*-value	*p*-value
Intercept				
Attendance pattern				
Exclusively part-time	-0.212	0.100	-2.171	0.031
Mixed full-time and part-time	0.054	0.070	0.825	0.410
Total aid amount	0.107	0.070	1.606	0.110
TRIO program eligibility criteria				
Low income and first generation	-0.136	0.090	-1.495	0.137
Low income and not first generation	-0.025	0.110	-0.219	0.827
First generation and not low income	-0.118	0.100	-1.129	0.260
Dependency status				
Independent student	-0.097	0.090	-1.126	0.262

Table 18 shows the odds ratio results for the logistic regression. The odds ratio results indicated that independent students were approximately 35% less likely to be retained than dependent students. Students attending postsecondary education on an exclusively part-time basis in the 2011-2012 academic year were almost 58% less likely to be retained than those who attended full-time, while those with a mixed attendance pattern were approximately 43% more likely to be retained than those attending just full-time. Finally, all variables for the

TRIO program eligibility criteria were between approximately 20 to 55% less likely to be retained than the reference (not low income and not first generation).

Because total aid amount is a continuous variable, no comparisons to a reference group could be made in the odds ratio results. The only variable having a statistically significant impact on the prediction was the part-time attendance pattern (p = .047).

Table 18

Odds Ratio Results for Research Question 5

Predictor	Odds Ratio	Lower 95%	Upper 95%	*t*-value	*p*-value	*b*-value
Intercept	2.364	0.993	5.631	1.955	0.052	0.860
Attendance pattern						
Exclusively part-time	0.423	0.181	0.988	-2.001	0.047	-0.860
Mixed full-time and part-time	1.432	0.607	3.378	0.824	0.411	0.359
Total aid amount	1.000	1.000	1.000	1.293	0.197	0.000
TRIO program eligibility criteria						
Low income and first generation	0.506	0.204	1.252	-1.484	0.139	-0.682
Low income and not first generation	0.813	0.145	4.558	-0.236	0.814	-0.207
First generation and not low income	0.558	0.201	1.550	-1.126	0.262	-0.583

Table 18 (Continued)

Predictor	Odds Ratio	Lower 95%	Upper 95%	*t*-value	*p*-value	*b*-value
Dependency status						
Independent student	0.645	0.296	1.408	-1.108	0.269	-0.439

Chapter Summary

This chapter presented the analysis of the retention of community college engineering and engineering technology students who began postsecondary education for the first time in the 2011-2012 academic year. Five research questions and five corresponding null hypotheses guided the research. Demographic data on the sample population were also presented. A chi-square test was used to evaluate the first research question, while logistic regressions were used to evaluate the following four research questions. From these tests, Null Hypotheses 1, 2, and 4 were retained, while Null Hypotheses 3 and 5 were rejected. The retention rate of community college engineering and engineering technology students is no different than the retention rate of the overall community college student population. Individually, academic and student background variables did not have a significant impact on the prediction of retention of community college engineering and engineering technology students, but financial variables did. When all significant academic, financial, and student background variables were combined, the combination had a significant impact on the prediction of retention of such students. A summary of these findings as well as conclusions, implications, and recommendations for future research are presented in Chapter 5.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter includes a summary of findings, conclusions, implications for practice, and recommendations for future research. The purpose of this study was to examine the academic, financial, and student background factors influencing the first-to-second year retention of engineering and engineering technology students at U.S. community colleges. An ex-pos-facto non-experimental quantitative study was conducted to provide a more in-depth understanding of the retention patterns of this subset of the community college student population. Analysis of the five research questions was done using a chi-square test and multiple logistic regressions. Data were obtained from the National Center for Education Statistics (NCES) Beginning Postsecondary Students 2012/2014 (BPS: 12/14) study, and the majority of the computations were conducted using PowerStats, a web-based statistical tool provided by the NCES. IBM SPSS 25 was used to conduct the chi-square test because PowerStats does not provide chi-square testing capabilities natively.

The sample population consisted of students who entered postsecondary education for the first time in the 2011-2012 academic year and enrolled in engineering or engineering technology programs at community colleges. The first-to-second year retention rate of these students was compared to the same rate for the overall community college student population minus engineering and engineering technology majors. In addition, select variables were identified from the dataset and grouped into the categories of academic, financial, and student background variables. These groupings were used as individual models to predict first-to-second year retention of community college engineering and engineering technology students using logistic regressions. Finally, individual variables that displayed statistical significance were then combined and were used as a model to predict student retention with a logistic regression.

Summary of Findings

The majority of the 98 students in the weighted sample of community college engineering and engineering technology students in this study were male, with female students comprising only 6% of the sample. Approximately 68% of males and 48% of females were retained from the first to second year, though PowerStats noted that the retention rate for female students should be analyzed with caution given the low response rate. As discussed in Chapter 2, community college engineering and engineering technology programs traditionally experience high attrition and low completion rates for female students (Hill, Corbett, & St. Rose, 2010).

The sample of engineering and engineering technology students featured in this study was predominantly of the traditional college age; nearly 80% were under the age of 24. This age distribution is similar to the distribution from Van Noy and Zeidenberg's 2014 study, where 83% of community college engineering students and 66% of engineering technology students were between the ages of 18 and 24. Students of the traditional college age were generally more likely to be retained than older students, with the exception of students in their thirties that had a noticeably high retention rate.

The limited sample size made obtaining data on the retention rates of specific races in PowerStats virtually impossible. Instead, the groupings of white vs. non-white students were used. Surprisingly, white students (72.3%) and non-white students (65.5%) were retained at relatively high rates, with non-white students comprising approximately one-third of the sample. Similar to the age groupings, the racial distribution in this study was consistent with the population distribution from the Van Noy and Zeidenberg (2014) study, where both community college engineering programs (61%) and technology programs (68%) were predominantly white.

Research Question 1 compared community college engineering and engineering technology student retention to that of all other community college majors. The results indicated that community college engineering and engineering technology students are not retained at a significantly different rate than non-engineering and engineering technology majors and are instead retained at a nearly identical rate as the combination of other majors. Though this study examined the transition from the student's first-to-second year only, other studies have also shown that retention rates for STEM based majors are not substantially different than those of other majors. Chen and Soldner (2013) found that the six-year retention rate for STEM majors was nearly identical to that of social/behavioral sciences, education, business, and humanities.

Groupings of academic, financial, and student background variables were used as predictors for community college engineering and engineering technology student retention. The grouping of academic variables in Research Question 2 did not have a significant impact on the retention of community college engineering and engineering technology students. An exclusively part-time attendance pattern had a significant impact towards to the retention model, and students attending on a part-time basis were approximately 76% less likely to be retained than those attending full-time. Though the overall model was not significant, the significant impact of attendance pattern on the model cannot be overlooked, as community college students are more likely to attend part-time and work full-time outside of school (Horn & Nevill, 2006). Students with a mixed attendance pattern were 6% more likely to be retained than those who attended exclusively full time.

The variable taking college level courses in high school had the strongest positive impact on the prediction of retention. Interestingly, students who did not take college-level courses in high school were approximately 82% more likely to be retained than those who did.

In general, the higher the student's high school GPA the more likely the student was to be retained, while a higher level of math taken in high school yielded a higher likelihood the student would be retained. This finding concurs with Chen and Soldner (2013), who found that approximately 47% of STEM students who did not complete algebra 2 or above in high school dropped out of college compared to nearly 30% of students who completed advanced level math courses in high school who dropped.

The grouping of financial variables in Research Question 3 did have a significant impact on the retention of engineering and engineering technology students at the community college level. The variables total aid amount and TRIO program eligibility criteria of low-income and first-generation status were statistically significant to the prediction model. Total aid amount had a significantly positive impact on the prediction of retention while the TRIO program eligibility criteria of low-income and first-generation status had a significantly negative impact on the prediction of retention. For the income group variable, the low, low-middle, and high-middle income groups were all more likely to be retained than the highest income group.

Students working part-time while enrolled were 35% more likely to be retained that students who are not employed while enrolled, while students working full-time were approximately one-half as likely to be retained. While not a statistically significant variable to the retention model, the findings related to employment agree with Mulski (2016), who after studying a two-year mechanical engineering technology program concluded that the number of hours a student works outside has a significant impact on retention. Van Noy and Zeidenberg (2014) found that 76% of community college STEM students were employed outside of school and worked on average 11 more hours per week than STEM students at four-year institutions.

A discrepancy was observed in the results for the grouping of financial variables. Students who were in lower- and middle-income groups were found to be more likely to be retained than higher income students. This finding does not concur with the results for the TRIO program eligibility criteria variable, where students who were low-income and not first-generation status, low-income and first-generation status, and not low-income and first-generation status were between 60 to 70% less likely to be retained than students who were not low-income and not-first generation status. The findings for the TRIO program eligibility criteria, specifically that lower-income and first-generation students are less likely to be retained than higher-income and not-first generation status, concur with other research on the topic of low-socioeconomic status (SES) student retention at the community college level (Bjorklund-Young, 2016; Devries, 2013; Roble, 2016; Zembrodt, 2019). Therefore, this leads the researcher to believe that the results for the income group variable are abnormal.

The grouping of student background variables in Research Question 4 did not have a significant impact on the retention of community college engineering and engineering technology students. The only variable category having a statistically significant impact on the prediction was the independent dependency status, which had a negative impact on the prediction of retention. The variable with the strongest positive impact on the prediction of was age. Female students were approximately 22% less likely to be retained than males and independent students were almost 75% less likely to be retained than dependent students. Students with a parent who attained a college were more likely to be retained than those who did not.

Finally, all academic, financial, and student background variables that displayed statistical significance in their respective predictor models were combined into a predictor model of their own in Research Question 5. The combination of statistically significant academic, financial, and student background variables did have a significant impact on predicting retention. A part-time attendance pattern was shown to have a statistically significant impact on the prediction of community college engineering and engineering technology student retention. The variable with the strongest positive impact on the prediction of retention of was the total aid amount, while the variable with the strongest negative impact on the prediction was an exclusively part-time attendance pattern.

The odds ratios of the logistic regression for Research Question 5 were congruent with the results from the previous three Research Questions. Independent students were again found to be less likely to be retained than dependent students. Students attending postsecondary education on an exclusively part-time basis were again found to be substantially less likely to be retained than those who attended full-time, but students with a mixed attendance pattern were more likely to be retained than those attending exclusively full-time. Finally, students who were low-income and not first-generation status, low-income and first-generation status, and not low-income and first-generation status were all less likely to be retained than students who were not low-income and not-first generation status.

Conclusions

An ex-pos-facto non-experimental quantitative study was conducted to provide a more in-depth understanding of the first-to-second year retention of community college engineering and engineering technology students. The extremely low number of female respondents (approximately 6%) indicates that the full picture of retention of female engineering and engineering technology students remains unclear. This study found a disparity between male and female engineering and engineering technology student enrollment, a finding consistent with the work Chen and Soldner (2013), Hill, Corbett, and St. Rose (2010), and Marra, Rodgers, Shen, and Bogue (2009) with regards to other groupings of female students. In fact, when compared to retention rates for male and female engineering and engineering technology students shown in this study, Chen and Soldner found a very similar percentage distribution of male (29%) and female (43%) retention across the overall community college population. Though the data presented in this study supports the general consensus of male and female retention patterns, the reasons why female student enrollment and retention remains so low in the engineering and engineering technology subset cannot be adequately determined by this study due to the low number of female participants.

Costello (2012) noted that the low cost and open accessibility of community colleges provide an entry point to higher education for minority students. Though community colleges may provide an open door to postsecondary education for minority students, engineering and engineering technology programs have traditionally experienced high attrition and low completion for minority students (Kendricks, Nedunuri, & Arment 2013; Marra, Rodgers, Shen, & Bogue 2009). This study found that, non-white students were approximately 8% less likely to be retained than white students. Though the retention rates were surprisingly high, the disparity in white vs. non-white retention is consistent with Chen and Soldner (2013), who showed that white students were at least 10% more likely to be retained than African-American and Hispanic students. The distribution of white vs. non-white students was also consistent with the racial distribution of Van Noy and Zeidenberg's 2014 study. Thus, a disparity continues to exist between the retention of white and minority students.

Overall community college graduation rates are traditionally poor, and these poor rates are often attributed to community colleges enrolling a higher number of low-income, academically underprepared, non-traditional, and minority students (Martin, Galentino, & Townsend, 2014). The majority of these findings were supported by this study, although lower-income students were shown to be more likely to be retained than their higher-income peers.

Yurtseven (2002) stated that many high school graduates are academically underprepared to study engineering in college because they have not taken a sufficient number of math, science, and technology-based courses in high school. Students who completed pre-calculus or below were less likely to be retained than those who completed calculus or above. The findings in this study supports the observations of Gandhi-Lee, Skaza, Marti, Schrader, and Orgill (2015) that engineering faculty would prefer that students take at least pre-calculus before entering an engineering program.

Chen and Soldner (2013) observed that of the students who entered community college STEM programs with a high school GPA of 2.5 or less, 41.8% eventually dropped out of college and 36.3% switched to a non-STEM major. This study found that students with a high school GPA less than 3.5 were less likely to be retained than those with GPA of 3.5 or above, with lower GPA's generally corresponding to lower odds of retention.

Another supplement to Martin, Galentino, and Townsend's (2014) conclusions that poor community college graduation rates can be attributed to community colleges enrolling a higher number of non-traditional and at-risk students was that non-traditional students were found to be the most vulnerable demographic featured in this study. Not only did the odds of being retained decrease with age, with the notable exception of students age 30 to 39, this study found that attendance pattern, specifically part-time attendance, had the most significant impact of any variable towards the prediction of retention of community college engineering and engineering technology students. When compared against other academic variables, part-time attendees were still approximately 68% less likely to be retained than full-time attendees. Taken a step further, when compared to other variables that displayed statistically significant p-values in prior research questions, part-time attendees were approximately 58% less likely to be retained than full-time attendees. The negative impact of part-time attendance on the prediction of retention of engineering and engineering technology students simply cannot be overlooked.

Although the results determined that academic variables did have a significant impact on the retention of community college engineering and engineering technology students, it is possible the results were skewed by the attendance pattern variable and its relatively low p-value (0.002). Much research has been discussed that shows academics as only a contributing factor to retention, rather than the primary predictor. As discussed in Chapter 2, much research exists that shows students who are leaving engineering are often doing well academically and aren't leaving for academic reasons (Geisinger & Raman, 2013; Seymour & Hewett, 1997; and Veenstra, Dey, & Herrin, 2009).

Finally, the conclusion that the engineering and engineering technology retention rate was almost identical (approximately 57%) to that of all other majors combined was also notable. This finding supports the data provided by Chen and Solder (2013) that showed the retention rate for STEM majors was consistent with other fields of study at the community college level. The similar retention rates of engineering and engineering technology majors and other community college majors found by this study lead the researcher to believe that the perceived difficulty of engineering and engineering technology majors over other collegiate majors, as discussed in Chapter 2, is perhaps more of a perception than a reality.

Implications for Practice

The following recommendations for practice have been developed based on the results of this research. The first recommendation is that community college engineering and engineering technology faculty work more closely with faculty at high schools within the college's service area to align curricular focus, particularly for math courses, to better prepare students for the rigors of college. Strimel and Grubbs (2016) stated that many secondary level educators teaching engineering and engineering technology subjects have never taken college level courses in those fields, as they are not required to for their job. To ensure a standard of quality in secondary engineering technology programs, and to adequately prepare students for entry to such programs in college, they proposed a nationwide engineering teaching licensure.

While affecting change to the teacher licensure on a national level would be a slow, arduous process, forward-thinking administrators at both the secondary and postsecondary levels could facilitate better communication on the academic expectations of both curricula and facilitate pedagogical collaboration. Also worth considering are facility tours and job shadowing opportunities for high school level faculty, an idea put to practice South Carolina Advanced Technological Education (SC ATE) Center of Excellence (Wood & Craft, 2001). This allows high school level faculty the same opportunities community college engineering and engineering technology faculty are provided with regards to understanding the needs of industry and the role of prospective graduates in the workplace.

Secondly, the stark negative impact of part-time attendance towards engineering and engineering technology student retention could potentially be offset if the student is taking a part-time course load in addition to co-op or paid internship opportunity. Instead of employment and education being separate compartments within the life of the student, co-ops and internships would provide the student an opportunity to hone skills necessary for industry while being able to financially support themselves, albeit somewhat. No longer would external employment be a distraction but would instead be a teaching tool in addition to their other traditional classes.

Third, the results of this study showed that students from lower-income backgrounds were more likely to be retained than those from higher-income backgrounds. This means that those in lower-income settings are potentially receiving enough financial aid to persist to the second year and are likely not at an academic disadvantage due to their financial situation. If community colleges are to provide the open door to higher education for minority students, as noted by Costello (2012), then this finding presents an opportunity for community college marketing and public relations departments to use as a selling point. Retaining at-risk students should be a priority for any community college system attempting to answer the challenge outlined by PCAST to produce 1 million STEM graduates by 2022.

Finally, if the PCAST goal is to be reached, then it is vital for community college engineering and engineering technology programs to place more effort on the recruitment and retention of female students. Though the problem is well documented, the results of this study indicate that female enrollment is a miniscule amount of the overall population of such students. It is impossible to fully know how retention strategies applied to male engineering and engineering technology students can work for female students when the population of female students in such programs is less than 10%, as evidenced by this study. After all, retention strategies only work if there are students to retain. The options outlined by Hill, Corbett, and Rose (2010), including but not limited to the formation of women in engineering groups, the hiring of female faculty, and sponsoring social events and seminars focused on successful women in STEM can only be a true success if the audience that could stand to benefit the most from the efforts is present. As stated in Chapter 2, the advantage of retention strategies that aid both female and minority engineering and engineering technology student retention is that they are generally applicable to types of students in such programs (Lichtenstein, Chen, Smith, & Maldonado, 2013). This study, along with many others, have shown that female students, as well as minority students, continue to be underrepresented in the community college engineering and engineering technology landscape. Simply put, the goal of 1 million STEM graduates by 2022 by PCAST will not be met without correcting this longstanding obstacle.

Recommendations for Further Research

McCubbin (2003) concluded that it is impossible for one singular retention model to be designed to account for "every conceivable reason that every single departing student had for leaving higher education" and, therefore, a model that can "effectively describe the attrition behavior of the traditional student type will still have been a remarkable success" (McCubbin, 2003, p. 4). The similar retention rates of engineering and engineering technology majors and other community college majors lead the researcher to believe that generalized retention strategies for community college students could perhaps be applicable to the engineering and engineering technology subset. More research comparing the causes of student attrition in engineering and engineering technology programs to the causes of attrition of the overall community college student population is needed.

Little to no data exist on the degree to which community college engineering and engineering technology students enroll in online classes, or how taking such classes would affect their retention. Such data would provide a new and valuable contribution to the field, as online education has become commonplace in 21st century higher education. Engineering technology programs, notorious for a substantial hands-on learning component, continue to migrate towards the digital education world. However, the student is more likely to experience this form of pedagogy through elective and general education courses required as part of their degree program. Though not affecting core curriculum classes, this form of instruction still has an effect on the integration of the student with the institution, and therefore its impact should be studied further.

Finally, the most obvious recommendation is that further research specific to the engineering and engineering technology subset be conducted. The sample size of 98 students limited the researcher on the data points that could be obtained. The NCES provided a multitude of variables to choose from; some of which would have been desirable to include as academic, financial, and student background variables. However, the small sample size limited the choice of variables due to reporting standards not being met, and by not allowing certain variables to have a reference group large enough to use in logistic regression. As discussed in Chapter 3, the variables presented in this study were determined not necessarily be researcher choice, but by necessity. A standalone study centered on the engineering and engineering technology subset would paint a more accurate picture of not only the retention pattern of such students, but the enrollment and graduation patterns as well. The researcher also suggests future studies compare these metrics between individual groupings of engineering and engineering technology programs respectively, given the subtle but significant differences in the ideology of both fields of study.

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