PERSISTENCE OF ENGINEERING TRANSFER STUDENTS: IDENTIFYING STUDENT-INFLUENCED AND INSTITUTION-INFLUENCED ACADEMIC SUCCESS FACTORS

by

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ABSTRACT

COURTNEY SUSANNE GREEN. Persistence of Engineering Transfer Students: Identifying Student-Influenced and Institution-Influenced Academic Success Factors. (Under the direction of DRS. SANDRA DIKA AND XIAOXIA NEWTON)

This correlational study utilized secondary, longitudinal data to examine the extent to which student-influenced and institution-influenced factors predict the academic success and degree completion of engineering transfer students at public four-year institutions in North Carolina. The sample included students who transferred from community colleges to pursue baccalaureate degrees at UNC System institutions that offered engineering or engineering technology programs from 2009 to 2016. Based on the data structure, regression analyses were utilized to examine the factors that predict first-semester academic performance and persistence to baccalaureate degree attainment at the receiving institutions. The hierarchical organization of student-influenced factors, institution-influenced factors, and factors influenced by both student and institution were based on a modified version of Smith and Van Aken's (2020) literature-based conceptual framework on engineering transfer student persistence.

Results indicated that first-term academic performance is impacted by student background, college/department of engineering characteristics, and attempted and earned hours in the first semester. Further, persistence was affected by age, the amount of transfer credit, college/department of engineering characteristics, and cumulative GPA and total earned hours at the receiving institution by the student. This study provides practical and actionable findings that will aid four-year engineering institutions in increasing the academic success and persistence of vertical transfer students pursuing baccalaureate engineering degrees.

DEDICATION

This dissertation is dedicated to my parents, Bobby and Susan Green. Their love, encouragement, and unwavering confidence in me made all the difference. Without them, this would not have been possible.

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CHAPTER 1: INTRODUCTION

For decades, the recruitment and retention of engineering students in higher education have been a national priority to respond to the enduring demand for highly qualified science, technology, engineering, and mathematics (STEM) professionals (Fayer et al., 2017; National Academy of Sciences [NAS] et al., 2010). The yearly growth in professional engineering jobs is projected to continue for many years to come as the United States competes to remain a global leader in technological innovation (Torpey, 2018). To meet current and future workforce needs, national initiatives have been created to strengthen, grow, and diversify the STEM workforce (President's Council of Advisors on Science and Technology [PCAST], 2020). In addition, both the government and industry sectors have communicated the need for investing in and developing programs or redefining existing programs that broaden participation in engineering fields (National Science Foundation [NSF], 2016; PCAST, 2020).

Generally, these efforts in higher education have primarily focused on traditional-age students who matriculate from high school directly into four-year institutions; also known as first-time, first-year (FTFY) students (Ogilvie, 2017). However, several factors have prompted policymakers and researchers to shift their focus to students who enter engineering education by alternate pathways. First, while graduation rates for high school students have increased, the number of high school students has had slowing growth since 2017 (Western Interstate Commission for Higher Education [WICHE], 2020). More concerning is that starting in 2025, the number of high school graduates is projected to decline yearly until at least 2037 (WICHE, 2020). Secondly, student mobility in higher education has grown more prominent in the last two decades (Lee & Schneider, 2016). As a result, students who migrate from two-year to four-year institutions have become a significant subpopulation in higher education (Shapiro et al., 2018).

The growth of this student population has been attributed to several factors such as increasing social mobility through the attainment of advanced degrees (Dowd, 2007; Goldrick-Rab, 2010), increased higher educational costs (Doughtery & Kienzl, 2006; Mitchell & Kerr, 2019; NACME, 2016; Townsend & Wilson, 2006), and increased concerns about academic and economic competitiveness of the United States (Bahr et al., 2013; Lee & Schneider, 2016).

Community colleges serve as a vital gateway into higher education for many students. According to the American Association of Community Colleges (AACC), nearly 40 percent of all first-time first-year students were enrolled in a two-year institution during Fall 2019, with a headcount total for students enrolled in two-year colleges that academic year being 11.8 million students. In addition, community college students are a diverse student population. They are more likely to be students of color, women, work full-time, first-generation, low-income, students with disabilities, veterans, and older than FTFY students (AACC, 2021). Due to the heterogeneous makeup of community college students, National Academy of Engineering (NAE) and the National Research Council (NRC) have highlighted the importance of the community college transfer pathway in broadening participation to baccalaureate engineering degrees (NAE, 2005; Olson et al., 2012). Furthermore, strengthening vertical transfer pathways to engineering disciplines has positive implications for improving equity (Dowd, 2012; Terenzini et al., 2014) since it expands accessibility to advanced degrees that allow graduates to secure a higher quality of economic and social life (Baum et al., 2013; Dowd, 2012). However, to increase baccalaureate engineering degree attainment, policymakers and institutional agents will need to develop supportive policies and practices to prepare two-year college transfer students for a successful experience at four-year institutions.

Statement of the Problem

National statistics on post-secondary two-year to four-year (vertical) institutional transfer patterns suggest that only 15% of these students will transfer successfully (National Student Clearinghouse Research Center, 2021). After transfer, about 48% of vertical transfer students will earn a baccalaureate degree within six years of community college entry compared to 63% of FTFY students who started at public, four-year institutions (NCES, 2021). The disparity in degree attainment rates suggests that vertical transfer students face additional barriers in pursuing baccalaureate degree attainment compared to FTFY students. Such poor degree attainment rates have prompted discourse and concern by policymakers, researchers, and educators. As the nation faces an increased need to be globally competitive in engineering fields, community college transfer students are viewed as one of the best resources for improving baccalaureate degree attainment (Lee & Schneider, 2016; Smith et al., 2021).

NCES and the American Society of Engineering Educators (ASEE) do not collect or report national-level graduation rates for engineering transfer students. However, the degree attainment rates have minimally changed for undergraduate engineering students (ASEE, 2017). The ASEE report is based on a national survey of all engineering institutions that offer at least one ABET-accredited undergraduate engineering program, though only 28% of the institutions (i.e., 111 institutions) provided data. Findings from the report suggest that, on average, 58% of undergraduate engineering students graduated with a baccalaureate engineering degree within six years; however, the graduation rates vary depending on gender, race, ethnicity, and type of institution (ASEE, 2017). In addition, the reporting institutions indicated that, on average, 13% of their engineering student population included transfer students. With the decline of high school graduates and more students starting their path in higher education through community colleges, understanding the persistence of engineering transfer students should be a focus for engineering education.

While student persistence in undergraduate STEM majors has received much attention over the last several decades, the transfer pathway for engineering students has only started to receive attention in the previous decade. In 2011, NAE and NRC hosted a national summit with higher education leaders to discuss barriers and opportunities to enhance vertical transfer pathways to engineering (Ogilvie, 2017). Meeting participants acknowledged the need for more research on recruitment, transfer, retention, and persistence to baccalaureate engineering degrees to examine the experiences of this population of students. When discussing achievement gaps and breaking down barriers within and between institutions, leaders in engineering education acknowledged that there are fundamental gaps of knowledge. Participants emphasized the lack of data in specific critical fields, which made it difficult to determine how to improve the success of vertical transfer students in engineering. The meeting discussants recognized the need for a comprehensive and coordinated plan for researchers, policymakers, educators, and industry leaders to enhance the two-year to four-year institution pathway.

It has been over a decade since the NAE and NRC summit, and the body of literature on engineering transfer student success and persistence remains sparse. Smith and Van Aken's (2020) systematic literature review on the persistence of engineering transfer students found that few studies have explicitly focused on engineering transfer student pathways and their success post-transfer. Instead, most research on the engineering transfer student population concentrates on pre-transfer academic outcomes or, more broadly, STEM transfer students. Previous research on transfer student academic success in STEM fields have identified common post-transfer challenges. However, the body of literature on the vertical transfer pathway in STEM is not robust enough to make conclusions about "programmatic features that are necessary to design effective STEM transfer pathways" (Dowd, 2012, p. 112).

In particular, there is empirical evidence indicating group differences in persistence between STEM majors. For example, when examining academic performance post-transfer and its impact on STEM major choice and persistence, two studies found that engineering majors are less likely to leave their majors than their science and math counterparts (Almatrafi & Johri, 2017; Lakin & Cardenas Elliot, 2016). In addition, engineering majors who change their majors are more likely to remain in a STEM college than science and math majors who change to non-STEM majors (Lakin & Cardenas Elliot, 2016). These group differences point to the need to examine engineering transfer students.

Previous research on transfer student success in STEM fields has identified challenges post-transfer related to the receiving institution's academic norms (e.g., increased pace of instruction, coursework rigor, and larger class size compared to two-year institutions); unwelcoming or “chilly” academic environments; inadequate academic advising and student support services; insufficient peer or faculty mentoring opportunities; and experiencing discrimination or microaggressions on perceived academic abilities based on race and gender (Chen, 2013; Fematt et al., 2021; Hoffman et al., 2010; Jackson & Laanan, 2015). In particular, vertical transfer students in engineering described having more negative environmental experiences post-transfer compared to students who transferred from four-year institutions (i.e., lateral transfer) (Davis et al., 2017). However, the existing knowledge about the persistence of vertical transfer students in engineering majors at four-year institutions is slim and fragmented (Ogilvie, 2015).

The following dissertation study addresses the impact of institutional characteristics on the persistence of vertical transfer students and expands on the limited literature on the vertical transfer pathway in engineering. Researchers have started to define vertical transfer student profiles and academic outcomes in engineering (Blash et al., 2012; Didion, 2015; Laanan et al., 2011; Ogilvie, 2017; Shealey et al., 2013) and explore their experiences post-transfer (Davis et al., 2017; Lakin & Cardenas Elliot, 2016; Lee & Schneider, 2016; Mobley & Brawner, 2014; Ogilvie, 2017). However, there is much left to learn about the vertical transfer pathway to baccalaureate engineering degrees. In particular, few studies have utilized advanced statistical methodologies using multi-institutional or statewide samples to understand how higher education systems structures within states promote (or detract) from the persistence of engineering transfer students. Specifically, there is a lack of knowledge on how different institution types in the same state influence vertical transfer students' academic success and their decision to persist in engineering.

The University of North Carolina System

North Carolina was the first to introduce the concept of a public university in the United States, and the state has remained dedicated to being a leader in higher education (The University of North Carolina [UNC] System, 2021). In North Carolina, all public institutions that grant four-year baccalaureate degrees are part of the UNC System. The UNC System consists of 16 universities across the state, five of which offer baccalaureate engineering degrees. The engineering institutions differ in size, setting, faculty makeup, admission requirements, research activity, and undergraduate population characteristics. However, while there are differences, all engineering institutions have a shared mission to "discover, create, transmit, and apply knowledge to address the needs of individuals and society" (The UNC System, 2021, Mission Statement, para. 2).

The UNC System and North Carolina (NC) Community College System have partnered to create a statewide Comprehensive Articulation Agreement (CAA) that establishes the transfer of credits between NC community colleges and the UNC System. Additionally, individual UNC System institutions have established selective partnerships with nearby community colleges. These partnerships aim to ease the transfer process and encourage more students to transfer to universities following their studies at the community college. Recent data suggests that 80% of community college transfer students migrate to public or private universities in North Carolina (D’Amico & Chapman, 2018). Over the last four decades, there has been steady growth in the number of NC vertical transfer students to UNC System universities. However, North Carolina data suggest differences in retention and graduation rates between North Carolina vertical transfer students and UNC System first-year first-time (i.e., non-transfer) students (D’Amico & Chapman, 2018).

Understanding the experiences of North Carolina vertical transfer students in engineering majors at four-year institutions is essential in understanding the overall adjustment of transfer students. Given the dynamic nature of student mobility in higher education, this study aims to assist administrators and educators at receiving institutions in understanding the institutional factors that ease the transfer process and promote the persistence of this growing subpopulation of students. Additionally, a state level investigation will benefit engineering colleges (or departments) interested in broadening student enrollment. Finally, the findings from this study could better position institutional agents in recruiting, retaining, and graduating vertical transfer students in the future.

Purpose of the Study

The purpose of this dissertation study was to determine what student-influenced and institution-influenced factors predict academic success and persistence related to the vertical transfer of undergraduate engineering students in North Carolina. Specifically, this study looked at students who started their journey in higher education at community colleges and matriculated to four-year institutions in the UNC system. Given the lack of knowledge on the relationship between vertical transfer student persistence and types of receiving institutions, this study aimed to uncover the influence of the contextual and climatic structure of the engineering department at the receiving institution on student academic outcomes over and above the influence of student background. The findings of this study can inform the improvement of existing college and academic advising practices at both the two- and four-year levels. Previous research on engineering transfer students has been limited to smaller samples or has failed to investigate how engineering college characteristics impact academic performance post-transfer and persistence in undergraduate engineering programs.

Research Questions

This study examined the student and institutional factors that influence the academic success and persistence of transfer students who pursued a baccalaureate degree in engineering in the UNC System from 2009 to 2016. In addition, this study will provide insights to UNC System institutions that offer baccalaureate engineering programs to support transfer students' successful transfer and persistence by addressing the following research questions.

1. How do student and institutional factors predict the academic success of engineering transfer students in their first term at the receiving institution?

2. How do institution-influenced factors moderate the relationship between pre-transfer academic factors and the academic success of engineering transfer students during their first term at the receiving institution?
3. How do student and institutional factors predict baccalaureate engineering degree attainment of transfer students?
4. How do institution-influenced factors moderate the relationship between post-transfer academic factors and baccalaureate engineering degree attainment?

Theoretical Framework

The guiding framework for this study is based on Smith and Van Aken's (2020) literature-based conceptual model for engineering transfer student persistence, which they adapted from Tinto's (1993) Theory of Integration. The conceptual model consists of three major categories of existing factors identified as affecting baccalaureate engineering degree attainment for transfer students: (a) student-influenced, (b) institution-influenced, and (c) student-influenced and institution-influenced. Pre-entry characteristics are student-influenced factors and include student characteristics and community college academic factors such as GPA, number of credits completed, and completion of an associate degree. The academic advising and engineering department environment is described as institutional-influenced factors. Institutional experiences, including the student's academics at the receiving institution, are described as student-influenced and institution-influenced factors. This category acknowledges the interactive relationship between the college/department of engineering environment and academic outcomes. The present study did not address all of Smith and Van Aken's model predictors, particularly student integration, goals, or motivation. However, the predictors in this study aligned with the three categories of Smith and Van Aken's model and offer a perspective that includes unique characteristics to the transition that engineering transfer students experience.

Research Design

A nonexperimental, correlational design using secondary institutional data was utilized in this study to understand the factors that contribute to the academic success and persistence of vertical transfer students in engineering. Data from the UNC System of students who transferred from community colleges to one of the five UNC System institutions that offer baccalaureate engineering degrees was examined. The five institutions include East Carolina University (ECU), North Carolina State University (NC State), North Carolina Agricultural and Technical State University (NC A&T), the University of North Carolina at Charlotte (Charlotte), and Western Carolina University (WCU). Only students who transferred between 2009 and 2016 are included in the study.

Multiple linear regression was utilized to examine which student and institutional factors, and factors considered to be influenced by both student and institution predict the academic success of transfer students during the first term at the receiving institution. First-term GPA will be used as a measure of academic success. A binary logistic regression was employed to examine the extent to which student-influenced factors, institution-influenced factors, and factors influenced by both predict the persistence of engineering transfer students. Baccalaureate engineering degree attainment was utilized as a measure of persistence. Due to there being five institutions in the UNC System that offer baccalaureate engineering degrees, single-level modeling was deemed appropriate. Both regression models (i.e., multiple and logistic) included interaction terms between the variables pertaining to student academic factors and variables of institutional characteristics to estimate moderating effects.

Transfer student data were obtained from a UNC System dataset prepared by the Belk Center for Community College Leadership and Research at NC State. Each university's institutional research office compiled institutional data, including faculty demographics and average engineering class size. In addition, the college of engineering or department of engineering at each university reported data on advising practices, and student orientation offered to transfer students. Lastly, university characteristics (i.e., institution type, size, and selectivity) were obtained by the researcher from the publicly available Carnegie Classification of Institutes of Higher Education datasets.

Significance of the Study

Over the past few decades, student mobility at post-secondary institutions has become increasingly prominent. In particular, a rising number of students begin their pursuits of higher education at two-year institutions and transfer to four-year institutions to pursue advanced degrees (AACC, 2021). Though, the transition from two-year to four-year institutions can be challenging for this subpopulation of students. Evidence on the differential degree attainment rates of vertical transfer students, compared to FTFY students, suggests that these students face additional barriers in pursuing baccalaureate degrees. Previous research on transfer students in STEM fields has demonstrated the existence and impact of declines in academic performance post-transfer (referred to as transfer shock). Still, few studies have been devoted to understanding how contextual factors affect academic outcomes and engineering major persistence.

The lack of research on the academic outcomes and persistence of vertical transfer students in engineering is problematic. Leaders in engineering education have recognized that it is critical to support the transfer pathway into engineering to broaden participation in the field. However, the lack of essential data on the transfer pathway has made it difficult to recruit, retain, and graduate this subpopulation of students. Findings from meticulously constructed research will assist policymakers, and higher education administrators in developing policies and practices to enhance this pathway. In addition, understanding the factors that contribute to successful vertical transfer and baccalaureate engineering degree attainment can increase these students' recruitment, retention, and persistence. This study, focused on vertical transfer students in North Carolina, intended to meet this objective by extending findings on engineering transfer student persistence by examining institutional characteristics that influence academic performance and persistence.

Definition of Key Terms

Academic advisor. Refers to professional staff hired by a higher education institution to advise and assist students with their academic plans of study.

Community college. A higher education institution where an associate's degree is the highest degree awarded. This definition includes comprehensive two-year colleges that offer both general education and technical programs and public and private technical institutions. Community colleges also award certificates and diplomas that require fewer credit hours than associate's degrees.

Engineering degree. Describes completion of baccalaureate programs coded in the Classification of Instructional Programs (CIP) as Engineering (CIP code 14).

Engineering technology degree. Describes completion baccalaureate programs coded in the CIP as Engineering Technologies/Technicians (CIP code 15).

Four-year institution. A higher education institution that awards baccalaureate degrees. Four-year institutions can be public or private and are commonly referred to as colleges or universities. In this study, the four-year institutions are five public universities that offer baccalaureate engineering degrees in the UNC System.

First-time, first-year (FTFY) students. A term used at four-year institutions to describe students who matriculate directly from high school to a four-year institution and are enrolled in a minimum of 12 credit hours. Typically, these students enroll in the fall term and are attending a four-year institution for the first time. This term also includes students who enter the university with advanced standing (college credit earned before high school graduation). The definition is adapted from the National Center for Educational Statistics (2021).

Lateral transfer. Describes student migration from a four-year institution to another four-year institution in higher education (Shealy et al., 2013).

Pre-transfer academics. Refers to a transfer student's academic performance at the sending institution. In this study, pre-transfer academics is limited to transfer hours and associate's degree award, including Associate of Arts, Associate in Science, Associate of Applied Science, or Associate in General Studies.

Post-transfer academics. A student's academic performance at the receiving institution includes attempted and earned credit hours and GPA at the receiving institution.

Receiving institution. The higher education institution where a student is enrolled after transfer. In this study, a receiving institution is a four-year public university in the UNC System.

Sending institution. The higher education institution where a student was enrolled and earned credit before transfer. In this study, sending institution is limited to two-year institutions.

Transfer hours. Academic credit hours that the receiving institution accepts. In this study, transfer hours are obtained by the student at a two-year institution.

Two-year institution. A higher education institution where an associate's degree is the highest degree awarded. This definition includes comprehensive two-year colleges that offer both general education and technical programs and public and private technical institutions. Two-year institutions also award certificates and diplomas that require fewer credit hours than associate's degrees.

Transfer student. Describes any student who migrates from one higher education institution to another (Shealy et al., 2013).

Vertical transfer. Describes student migration from a two-year institution to a four-year institution in higher education (Shealy et al., 2013).

Dissertation Organization

This study was designed to build upon prior research regarding the academic success and persistence of engineering transfer students. Specifically, this study sought to understand the role of a receiving institution's characteristics in decreasing transfer shock and increasing the baccalaureate degree attainment of engineering transfer students.

Chapter 2 synthesizes recent literature on engineering transfer student persistence and includes key concepts of the theoretical framework that guides this study. The conceptual framework provided a structure for student characteristics, pre-transfer and post-transfer academics, and institutional culture that contribute to the persistence of engineering transfer students. In addition, emergent themes and gaps in the literature are presented. In Chapter 3, the methodology utilized for this study is outlined. The data analysis and results are described in Chapter 4. Lastly, Chapter 5 presents a discussion on the findings by each research question, limitations of the study, and implications and recommendations for future research, policy and practice.

Summary

Nearly half of all students who embark on a post-secondary education begin their journey at two-year institutions (AACC, 2021). A significant portion of these students will continue their education at four-year institutions to pursue advanced degrees. Evidence suggests a disparity between FTFY and vertical transfer students' rates of baccalaureate degree attainment (National Clearinghouse Research Center, 2021). The poor rate of degree attainment has prompted discourse and concern among policymakers, researchers, and practitioners. Specifically, as governmental and industry sectors demand an increase in highly-qualified engineering professionals, community college transfer students are viewed as one of the greatest means for improving advanced degree attainment (Ogilvie, 2017; Smith & Van Aken, 2020).

Given the increasing use of two-year institutions as a pathway to STEM careers (Hoffman et al., 2010) and the use of two-year institutions by minoritized groups, promoting the success of these students is vital. Improving the vertical transfer pathway to baccalaureate engineering degrees is paramount in (a) increasing social and economic mobility of a diverse subpopulation of students (Dowd, 2012; Terenzini et al., 2014); (b) broadening participation in engineering; and (c) meeting current and future national demands for having a highly qualified engineering workforce. Due to the shortage of knowledge, empirical research is necessary to determine how institutional context promotes or detracts from the academic performance and the persistence of this subpopulation of students. Understanding the institutional characteristics experienced by vertical transfer students in engineering majors at four-year institutions is crucial in understanding the overall adjustment of transfer students.

CHAPTER 2: LITERATURE REVIEW

Engineering has driven innovation critical for the economic growth and productivity of the United States since the American Revolution in 1775 (National Academy of Sciences [NAS] et al., 2010). Between 2017 and 2027, the Bureau of Labor Statistics has predicted that engineering-related occupations will increase at a rate of 10 to 23%, creating an additional 500,000 new engineering job openings (Fayer et al., 2017). In the last twenty years, recruitment and retention efforts to meet engineering workforce demands have primarily focused on FTFY students who matriculate from high school directly into four-year institutions (Ogilvie, 2017). However, Western Interstate Commission for Higher Education (WICHE) found that the number of high school graduates will start to decline moderately in 2025 and will continue to decline through 2037 (WICHE, 2020). Increasing undergraduate engineering enrollment and graduation rates will continue to be a national priority as the necessity of a highly qualified engineering workforce continues to grow while the supply of engineering degree earners is projected to decrease (Fayer et al., 2017; Smith & Van Aken, 2020).

The projected steady decline of high school graduates and changing profile of undergraduate degree seekers will require educators, administrators, and policymakers to be proactive in their approaches to recruiting, educating, and retaining engineering students. A sustainable solution is to look at the growing number of engineering students who pursue higher education at two-year institutions. Community colleges serve as a gateway to higher education for a substantial number of students, with nearly half of students matriculating to two-year institutions following graduation from high school (Columbia University, 2019). Moreover, the number of students who transfer vertically to pursue engineering degrees continues to grow. Before COVID-19, the 2018 National Student Clearinghouse (NCR) report showed that 22% of students navigate a two-year to four-year institutional transfer pathway, a 2% increase from the 2012 report (Hossler et al., 2012; Shapiro et al., 2018).

The persistence of vertical transfer students is necessary to meet industry demands, which requires a better understanding of the factors that either promote or detract from their persistence. Understanding these factors will allow two-year and four-year institutions to develop pragmatic policies and programming that can make a positive impact on the persistence of engineering transfer students. Unfortunately, the body of literature on the persistence of engineering students is focused mainly on either full-time first-year students or more broadly focused on transfer students in STEM (Dowd, 2012; Ogilvie, 2017; Smith and Van Aken, 2020; Wetzstein, et al., 2020). In 2011, the National Academy of Engineering (NAE) and the American Society of Engineering Education (ASEE) undertook a pilot study to explore the experiences of transfer students in engineering and engineering technology programs at 17 four-year institutions and 35 two-year institutions as a follow-up to the 2005 NAE report. The researchers encountered difficulty in identifying transfer students since there were inconsistent definitions of transfer students, which researchers have since attributed to "lack of readily available data" (Gibbons et al., 2011, p.2) and "inconsistent data collection methods" (Didion, 2015, p. 2). Since the 2011 pilot study, there has been an effort to improve the research in this field; however, there have been relatively few published studies on engineering transfer students (Laanan, et al., 2011; Laugerman, 2012; Laugerman & Shelley, 2013; Mickelson & Laugerman, 2011, Smith & Van Aken, 2020).

This literature review seeks to capture what is currently known about the characteristics, academic performance, and educational outcomes of vertical transfer students in engineering. EBSCOhost, ProQuest, and Engineering Village were chosen to locate peer-reviewed publications on engineering transfer students published between 2005 and 2021. To narrow the scope of the review, publications selected met the following criteria: (a) undergraduate students; excluded high school and graduate students; (b) transfer students from two-year institutions; excluded articles focused only on full-time, first-year students, or only lateral transfers; (c) engineering and STEM; excluded articles that do not explicitly discuss engineering; and (d) focused on post-transfer persistence in engineering disciplines.

The subsequent literature review was guided by the following questions:

(1) Why is a new conceptual framework necessary in understanding the persistence of engineer transfer students?

(2) What is the current state of literature on engineering transfer student persistence?

(3) What quantitative methodologies have been utilized to understand engineering student persistence?

(4) What student factors have been identified as being influential in the persistence of engineering transfer students?

(5) What institutional factors have been identified as being influential in the persistence of engineering transfer students?

(6) What are the gaps are there in the literature about the persistence of this population of students?

The following review is organized into five sections that align with the guiding questions and end with a summary. In the first section of the review, Smith and Van Aken's (2020) systematic literature review was drawn upon to evaluate the most commonly utilized theoretical frameworks researchers have employed to understand engineering transfer student persistence. This section includes a new literature-based conceptual model developed by Smith and Van

Aken that will be the guiding framework for this study. The next section briefly explores the current state of the literature and includes a review of methodologies used to evaluate the persistence of engineering transfer students. Researchers have utilized quantitative and qualitative approaches to understand the relationship between students' academic performance (pre-transfer and post-transfer) and their persistence to baccalaureate degree attainment. A focus will be on quantitative analytical methods since the present study is a quantitative study. A synthesis of recent literature on student and institution-influenced predictors of persistence will follow. The major themes include student demographics, pre-transfer academics, post-transfer academics, and institutional culture related to the department or college in which engineering programming is located. Next, institution culture at four-year institutions, which starts with orientation, has been analyzed to understand the impact on the persistence of this population. Last, a summary of the chapter is provided.

Conceptual Models for Engineering Transfer Student Persistence

In *Systematic Literature Review of Persistence of Engineering Transfer Students,* Smith and Van Aken (2020) highlighted four persistence frameworks that educational researchers commonly employed to understand and explain differences in engineering transfer students' persistence (see Astin, 1985; Laanan, 2004; Schlossberg, 1984; Tinto, 1993). However, it should be noted that only a quarter of the literature reviewed on this population utilized any theoretical framework. Smith and Van Aken found that the most cited framework was Astin's Theory of Involvement, appearing in the majority of publications that utilized a guiding framework (Bohanna, 2016; Jackson & Laanan, 2014, Lee & Schneider, 2016; Lopez, 2012; Lopez & Jones, 2017; Massi et al., 2012; Mendez, 2001). Astin's theory (1985) utilizes an input-environment-output model that asserts that student outcomes (e.g., academic, attitudes, and beliefs) are a function of inputs (student demographics, background, and previous experiences) and the environment (experiences at higher education institutions).

Tinto's Theory of Student Integration (1993) and Laanan's Transfer Student Capital (2004) are the second most cited persistence frameworks of studies that identified a guiding framework. Educational researchers have found support for Tinto's theory, suggesting that lack of social and academic integration is a critical predictor of student persistence (Evans & Mody-Pan, 2010; Marra et al., 2015; Massi et al., 2012). Tinto's framework posits that in addition to pre-college preparation and experiences, integration into a higher education institution's social and academic structure directly impacts a student's retention and persistence at that institution. Further, academic integration relates to learning, coursework, classroom climate, advising, and intellectual development (Evans & Mody-Pan, 2010). In contrast, social integration refers to peer interactions/culture, campus social activities, study groups, and the development of close friends at the institution (Evans & Mody-Pan, 2010). Thus, the degree to which a student integrates into the institution directly impacts persistence and degree attainment. Therefore, institutions can positively or negatively influence this progression through advising support, faculty training, student services, and other interventions.

Transfer Student Capital was coined by Laanan (2004) and is defined as the accumulation of knowledge about higher education that a student develops as the student interacts with their institution through experiences with faculty, advisors, coursework, and navigates through the transfer process from a two-year institution to a four-year institution. Educational researchers have used the concept of transfer capital to investigate engineering vertical transfer students' experiences and their adjustment at four-year institutions (Laanan et al., 2011; Mobley & Brawner 2013; Ogilvie, 2014). Following the term's inception, transfer student capital has been operationalized by Laanan (2010) using composite variables for academic advising experiences, perceptions of the transfer process, faculty experiences, and cognitive skills developed at the two-year institution. Laanan's theory suggests that the more transfer student capital a student has, the more likely they will be to successfully transition to a four-year institution (Laanan, 2010). Limitations of the Transfer Student Capital framework include lacking consideration of the successful completion of specific math and science courses (Calculus I and II, and at least one semester of physics) at the sending institution. Research studies have shown that completion of these math and science courses is a factor that influences the persistence of engineering transfer students (Darrow, 2012; Laugerman et al., 2015; Laugerman & Shelley, 2013).

Lastly, Schlossberg's Transition Theory (1984) was utilized as a persistence framework to aid in understanding the academic and social experiences of engineering transfer students in higher education in several studies (Hagler, 2015; Lakin & Cardenas Elliot, 2016). Transition Theory is broadly applied in psychology to any transition that an adult goes through in life. Schlossberg defines transition as "any event, or non-event, [which] results in changed relationships, routines, assumptions, and roles" (Goodman et al., 2006, p. 33). This theory posits that the regardless of transition event, the transition process is related to four factors that influence how an individual copes with transition: the situation, self, support networks, and effective coping strategies (Goodman et al., 2006). Limitations of Schlossberg's Transition Theory include lack of consideration of the interaction between the four factors and the applicability of the theoretical framework to diverse student populations.

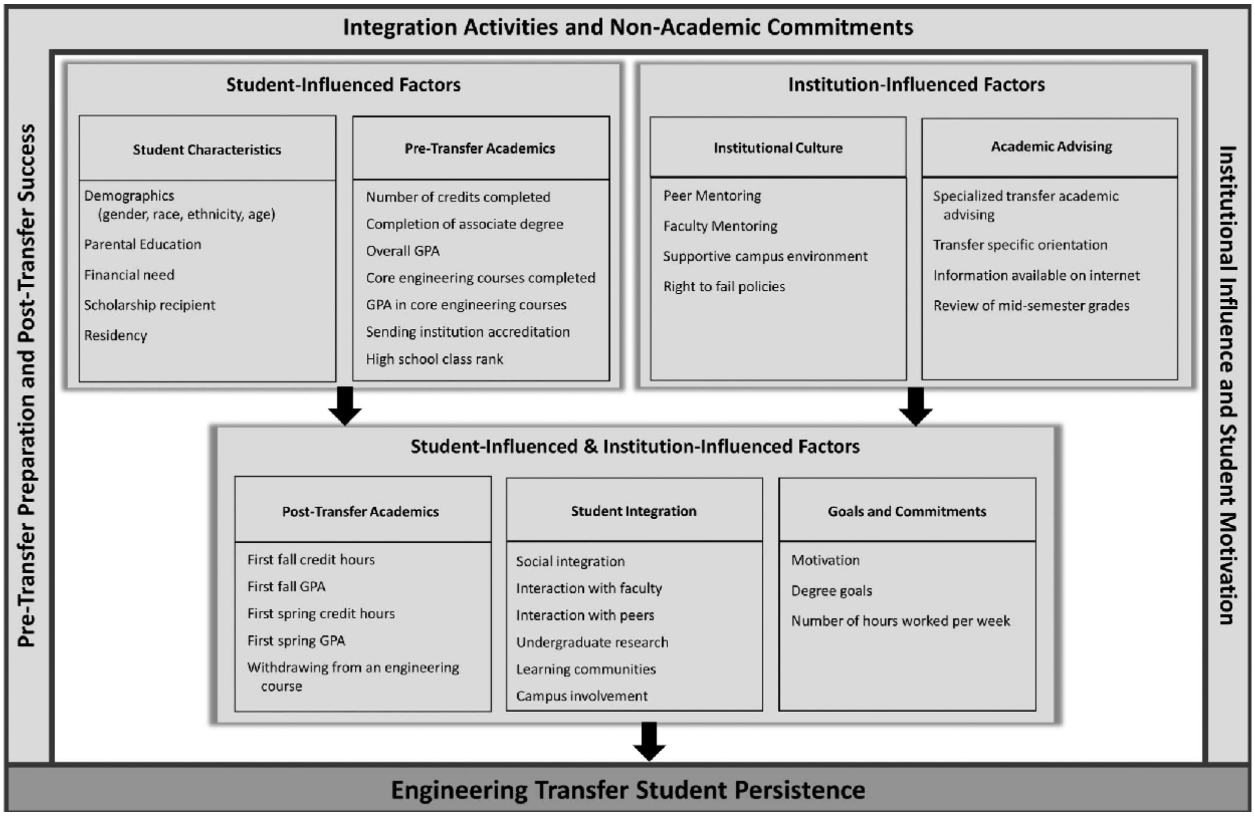
Smith and Van Aken posited that these commonly applied theoretical frameworks and models fail to include factors that have been identified as affecting student persistence unique to engineering transfer students. Both Astin's Theory of Involvement (1985) and Tinto's Theory of

Integration (1975) were initially conceptualized with FTFY students in mind within the four-year institution context. Critics argue that student engagement differs depending on major type where the culture of engagement in engineering is focused on improving quantitative skills through collaborative study and on the rewards in the job market post-graduation (Brint et al., 2008; Dika & Lim, 2012). Moreover, D'Amico and colleagues (2014) found that perceived academic integration at two-year institutions was the key predictor for academic outcomes. The researchers concluded that academic integration is more critical than social integration for this population of students.

Based on these critiques, Smith and Van Aken (2020) developed a three-category conceptual framework following a systematic literature review on the persistence of engineering transfer students. Their literature review included journal articles that only focused on post-transfer persistence and students specifically majoring in engineering. Smith and Van Aken's (2020) model is adapted from Tinto's (1993) Theory of Integration and includes factors specific to engineering transfer students. As a result, the following factors were incorporated into the model: (a) student-influenced factors, (b) institution-influenced factors, and (c) student-influenced and institution-influenced factors. Smith and Van Aken's theoretical model includes the interaction between a transfer students' pre- and post-transfer success and institution influence in relation to their persistence in undergraduate engineering programs which was missing from the previously described theoretical frameworks. Figure 1 presents Smith and Van Aken's (2020) complete conceptual framework for engineering transfer student persistence, which includes student integration, and goals and commitments. Figure 2 presents Smith and Van Aken's (2020) modified three category conceptual framework with the factors of interest for the current study.

Figure 1

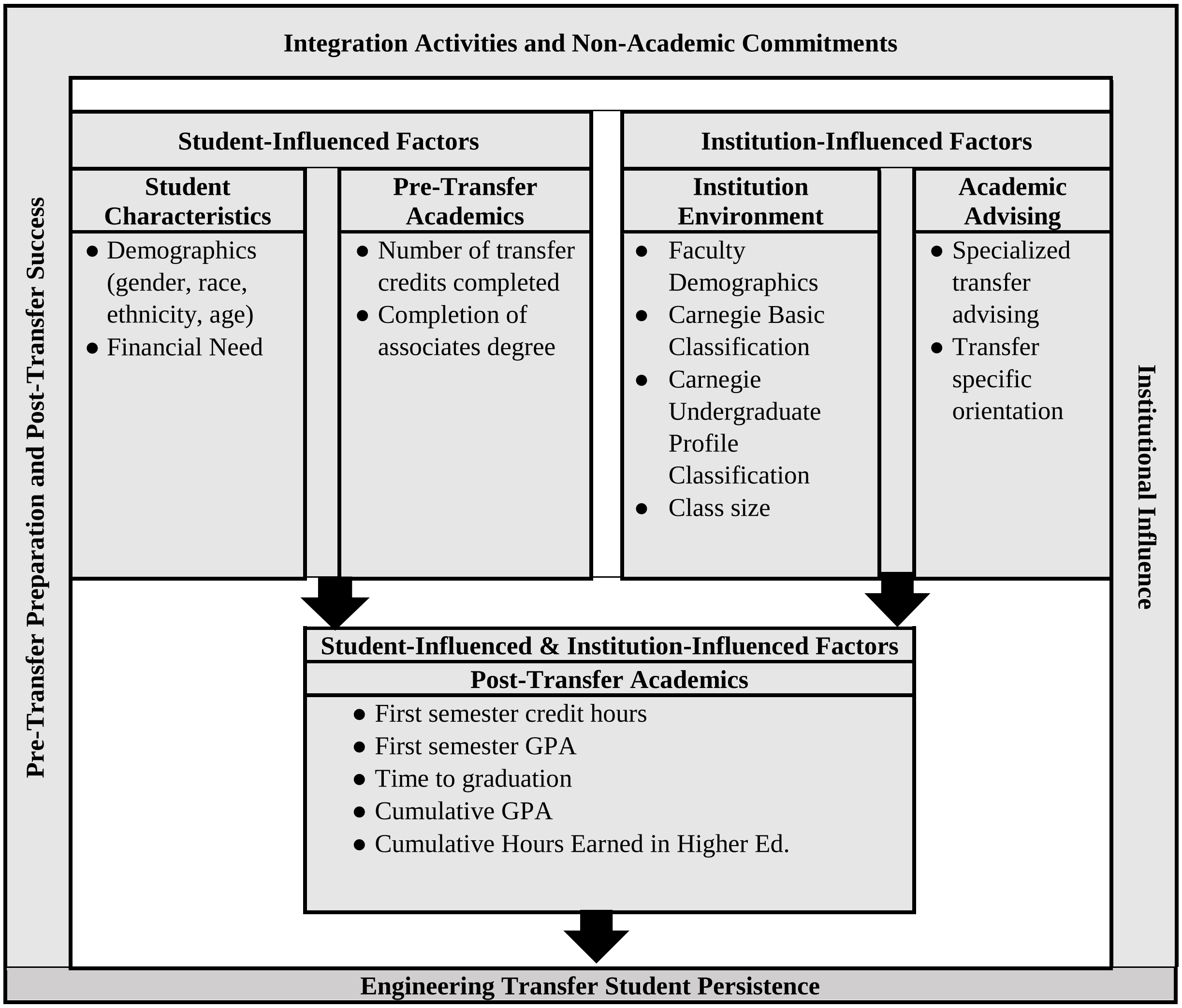
Conceptual Framework for Engineering Transfer Persistence



Note. Three category model for engineering student persistence based on a review of literature. From "Systematic Review of Persistence of Engineering Transfer Students, by N. L. Smith and E. M. Van Aken, 2020, *Journal of Engineering Education*, 109, p. 875.

Figure 2

Framework for Engineering Transfer Persistence for Present Study



Note. Modified from Smith and Van Aken's (2020) conceptual model of engineering transfer student persistence.

Pre-transfer characteristics are described as student-influenced factors and include student characteristics and community college academic factors such as number of credits completed, and completion of an associate degree. Student characteristics are demographics (i.e., gender, race, ethnicity, and age), and financial need. Academic advising and engineering department (or college of engineering) environment at the receiving institution can be described as institution-influenced factors. Institutional environment includes faculty demographics, Carnegie Basic Classification, Carnegie Undergraduate Profile Classification, and class size. A transfer student's institutional experiences, including their academics at the receiving institution, is described as factors influenced by both student and institution.

The next section briefly explores the current state of the literature and includes a review of methodologies used to evaluate the persistence of engineering transfer students. Researchers have utilized quantitative and qualitative approaches to understand the relationship between students' pre-transfer and post-transfer academic performance and their persistence post-transfer to four-year institutions. However, the focus of this review is on quantitative studies since the study utilized quantitative methods. A summary of the overarching themes and subtopics of the literature is presented in Table 1. Table 2 summarizes the research methodologies utilized to evaluate engineering transfer student persistence. Additionally, recommendations and best practices from the literature are reviewed.

Table 1

Themes and Subtopics in the Literature

Theme	Subtopic	Reference
Student Characteristics	Demographic	Cosentino et al., 2014*; Laanan et al., 2011; Lakin & Cardenas Elliot, 2016*; Lee & Schneider, 2016*; Shields & Pietroburgo, 2000*; Tkacik et al., 2012
	Financial Need	Cosentino et al., 2014*; Blash et al., 2012*
Pre-Transfer Academics	Amount of Transfer Credit	Anderson-Rowland et al., 2015; Lakin & Cardenas Elliot, 2016*; Lopez & Jones 2017*; Shields & Pietroburgo, 2000*
	Associate's Degree Attainment	Lee & Scheider, 2016*; Lopez, 2012*; Mattis & Sislin, 2005
	Overall GPA at two-year Institution	Blash et al, 2012*; Didion, 2015, Ogilvie, 2017, Anderson-Rowland, 2011*; Lakin & Cardenas Elliot, 2016*; Lopez & Jones, 2017*; Shields & Pietroburgo, 2000*
	Remedial Math	Blash et al., 2012*
Post-Transfer Academics	Number of Credits in 1st semester	Anderson-Rowland, 2009; Laier & Steadman, 2014*; Lakin & Cardenas Elliot, 2016*; Laugerman & Shelley, 2013*
	1st Semester GPA	Laugerman & Shelley, 2013*; Laugerman, et al., 2015*; Townley et al., 2013*
	Transfer Shock	Anderson-Rowland, 2011*; Lakin & Cardenas Elliot, 2016*; Laanan et al., 2011*
	Time to Graduation	Blash et al., 2012*; Laugerman & Shelley, 2013*
Institutional Culture	Peer and Faculty Mentoring Programs	Allen & Zhang, 2016; Anderson-Rowland, 2011*; Jackson et al., 2013; Olson et al., 2016; Sheinberg, 2015
	Specialized Transfer Advising	Anderson-Rowland, 2011*; Davis et al., 2017; Jones & Waggenspack, 2015*; Laanan et al., 2011*; Laier & Steadman, 2014*; Massi et. al, 2012*; Mobley & Brawner, 2014; Sarder, 2013;
	Transfer-specific Orientation	Anderson-Rowland, 2011*; Jackson et al., 2013; Jefferson et al., 2013; Jones & Waggenspack, 2015*; Laier & Steadman, 2014*; Massi et al., 2012*; Mobley & Brawner, 2014; Olson et al., 2016; Sarder, 2013; Sheinberg, 2015
	Articulation Agreements	Blash et al., 2012*; Shealy et al., 2013*
	Institutional Type	Shealy et al., 2013*
	Class Size	Fematt et al., 2021*

Note. * Denotes quantitative study.

Table 2

Summary of Quantitative Methodologies utilized in the Literature

Study	Sample Size	Data Source	Analyses
Anderson-Rowland, 2011	344 engineering and computer science transfers at ASU	Institutional Data	T-tests
Blash et al., 2012	4,219 engineering transfer students from 1996-2009 in CA	Survey	Descriptive statistics
Cosentino et al., 2014	8.790 African American engineering students (2,001 transfers) at 11 institutions	MIDFIELD dataset	Linear and Logistic Regression
Fematt et al., 2021	Three STEM transfer Cohorts: 417, 232, and 154 students at research-intensive university in CA	Survey	Latent class analysis
Jones & Waggenspack, 2015	4 Cohorts (total of 36) engineering transfer student scholarship recipients at LSU	Institutional data	Descriptive statistics
Laanan et al., 2011	157 engineering transfer students at Midwestern university	Laanan Transfer Student Questionnaire Survey (LTSQS)	Descriptive statistics
Laier & Steadman, 2014	115 engineering students (70 transfer) at University of South Alabama	Institutional data	Descriptive statistics
Laugerman et al., 2015	1,191 in-state vertical engineering transfers from 2002-2010- single institution	Institutional data	Descriptive statistics
Laugerman & Shelley, 2013	472 engineering transfer students at Midwestern university	Institutional data	Structural Equation Modeling
Lakin & Cardenas Elliot, 2016	20,000 students (including 2,273 transfer COE students) at large, research-intensive university in southeastern US	Institutional data	Descriptive and Logistic Regression
Lee & Schneider, 2016	860 students selected from national database	Longitudinal Survey	Logistic Regression
Lopez, 2012	80 engineering transfer students and 200 STEM non-engineering	LTSQS and Engineering Transfer Student Questionnaire	Descriptive, t-test, MANOVA, Multiple regression
Lopez & Jones, 2017	280 STEM students at Midwestern Research University	LTSQS	Descriptive and Multiple Linear Regression
Massi et al., 2012	1,042 engineering students (350 transfer) at University of Central Florida	Survey	ANOVA
Shealy et al., 2013	126 engineering students from MIDFIELD dataset (multiple institutions)	Survey	Descriptive
Shields & Pietroburgo, 2000	200 pre-engineering students (156 transfer) at Washington University	Institutional data	ANOVA

Table 2 continued

Study	Sample Size	Data Source	Analyses
Townley et al., 2013	53 STEM students at USC Columbia	Survey	Hierarchical Linear Regression, t-tests, cross-tabs

Current State of Literature and Methodologies for Understanding Persistence of Engineering Transfer Students

Following NAE and ASEE's joint research effort in 2011 to better understand the enrollment and demographic background of engineering and engineering technology transfer students, multiple studies have been published using large-scale, multi-institutional databases. The databases and studies include: (a) California Partnership for Achieving Student Success (Cal-PASS) (Blash et al., 2012), (b) Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD), includes 23 four-year institutions (Cosentino et al., 2014; Mobley & Brawner, 2014; Ohland et al., 2015; Shealy et al., 2013), (c) California Postsecondary Education Commission (CPEC) (Blash et al., 2012), and (d) Prototype to Production (P2P) project, comprised of 31 four-year institutions and 15 two-year institutions (Lattuca et al., 2006; Terenzini et al., 2014). The research designs included quantitative, qualitative, or mixed-method designs.

While researchers have utilized large databases, a review of methodologies utilized by researchers to explain the factors that influence the persistence of engineering transfer students has highlighted the lack of application of advanced statistical methods. The methodologies utilized by researchers to understand engineering transfer student persistence have largely been limited to descriptive statistics or qualitative methods. Furthermore, there is a scarcity of literature examining engineering transfer student persistence at more than a single institution.

Specifically, only four of the studies reviewed for this literature review included multiple institutions in their sample.

Of the few studies that utilized advanced statistical methods, multiple or logistic regression was utilized in four studies to understand transfer student persistence. Cosentino et al. (2014) modeled ordinary least square regressions for continuous variables and logistic regressions for dichotomous outcomes to control for gender, academic success (GPA), and other student characteristics to understand the effectiveness of the transfer pathway for African American engineering students. Only African American students were included in the study and academic outcomes (e.g., hours earned) and institutional characteristics were not included. Lee and Schneider (2016) utilized logistic regression to analyze the effects of institutional type to student persistence at 490 institutions. However, only the Carnegie Basic Classification was used to measure institutional characteristics. Lopez and Jones (2017) used linear regression to examine the factors that predict academic adjustment of two-year transfer students. The indicators used in their model were self-reported by students and only included students in one academic year. Townley et al. (2013) used two-level hierarchical linear regression to understand how sense of community and participation in STEM activities interacted with transfer students' post-transfer GPA. However, it should be noted that due to the small sample size in Townley et al.'s study there was insufficient power to detect potential associations.

Structural equation modeling was used in two studies to estimate the covariance structure based on hypothesized relationships between academic variables and outcome variables. Laugerman and Shelley's (2013) exploratory study found a reasonably good model fit of academic variables that influence the completion of an undergraduate engineering degree for community college transfer students. Fematt et al. (2021) utilized latent class analysis, a subset of structural equation modeling, and discovered meaningful subgroups of transfer students based on students' responses patterns to measure of academic and social adjustment. Both studies were conducted at a single institution so findings could be unique to the institution.

Overall, a review of literature has found differences in findings related to the persistence of engineering transfer students compared to their full-time, first-year counterparts. Several studies suggest that transfer students persist at lower rates than FTFY students (Ishitani, 2008; Sullivan et al., 2012). Other studies have found similar or slightly higher persistence rates for transfer students (Caralan & Byxbe, 2000; Glass & Harrington, 2002; Sullivan et al., 2012. Moreover, Cosentino et al.'s multi-institutional study (2014) found that gender and GPA, not transfer status, predicted graduation outcomes for Black engineering transfer students from two-year institutions.

In addition, several studies have found increased persistence of vertical transfer students in engineering at four-year institutions with strategic partnerships with community colleges in their respective states in the last five years. For example, the collaboration between Texas A&M University's Dwight Look College of Engineering and Blinn College-Bryan suggests that the impact of the partnership was statistically significant and provided the institutions a collaborative opportunity to "identify and remove academic, administrative, and transfer barriers in-situ" (Cortez et al., 2015, p. 11). Similarly, Didion (2015) highlighted the importance of transfer assistance programs between Missouri community colleges and Missouri University of Science and Technology (Missouri A&T) to create a "fairly transfer-friendly culture" (p. 8) and ensure that students have a seamless onboarding experience.

Only two reviews of literature were found on this specific population. Smith and Van Aken's (2020) systematic literature review on engineering transfer students included recommendations for institutions to improve the persistence of this population. Their recommendations for four-year institutions included "increasing pre-transfer academic requirements, increasing student integration, and providing an inclusive institutional culture" (p. 865). The second review (Ogilvie, 2014) focused on student experiences in the transfer process from two-year institutions and found gaps in the literature on transfer pathways and academic outcomes for these students. Gaps included exploring how engineering transfer student success at receiving institutions varies by race, gender, major, enrollment status, and how receiving institutions improve or hinder transfer student success in engineering degree programs.

Student-Influenced Factors of Persistence

The following is a synthesis of extant research which focused on student characteristics and educational outcomes before transfer to a four-year institution. In alignment with these focus areas, the following summarizes results from empirical research studies and identifies areas to further advance our understanding of this population of students. Student-influenced factors are based on either a student attribute or academic performance.

Student Characteristics

Student characteristics include factors that are broadly used to describe students. The students' sociodemographic characteristics include gender, race, ethnicity, age, and financial need. Numerous studies have utilized sociodemographic data on engineering transfer students to aid in the understanding of these students (Blash et al., 2012; Cortez et al., 2015; Didion, 2015; Sullivan et al., 2012). Several studies indicate that socio-demographic data for engineering transfer students is similar to the profile of traditional students, which is predominately White and male (Blash et al., 2012; Ohland et al., 2015). Conversely, other studies have discovered higher representations of transfer students who have been historically underrepresented in engineering, such as Hispanic or Latino students (Knight et al., 2014; Terenzini et al., 2014; Yoon et al., 2015; Didion, 2015), Black or African American students (Didion, 2015), and women (Gibbons et al., 2011) compared to FTFY students. These studies provide evidence that the community college to four-year institution pathway holds potential for increasing the representation of minoritized persons in engineering.

Congruent with literature on FTFY students (Tinto, 1993; Astin, 1999), a student's demographic background was a commonly identified variable impacting the persistence of transfer students. In addition, some studies suggested that transfer student demographics were independent factors that impacted persistence and degree attainment (Lee & Schneider, 2016; Tkacik et al., 2012). In comparison, other studies discovered an interaction of between gender, race, ethnicity, or age as influencing the persistence and academic success of engineering transfer students (Cosentino et al., 2014; Lakin & Cardenas Elliot, 2016). Cosentino et al. (2014) found that Black women consistently outperformed and out persisted Black males once they transferred into engineering programs at four-year institutions, while Lakin and Cardenas Elliot (2016) found that Black and women engineering transfer students had significantly greater drop in GPA post-transfer but were no less likely to leave their major compared to non-engineering majors.

Engineering transfer students tend to be slightly older than their traditional student counterparts (Laanan et al., 2011; Ogilvie, 2014). This finding reaffirms the broader community college literature. Specifically, engineering transfer students and community college students were revealed to be, on average, two years older than traditional students when starting their pursuit in higher education (Knight et al., 2014; Terenzini et al., 2014). By the time of baccalaureate degree attainment, the researchers found that engineering transfer students were, on average, 5 to 7 years older than traditional students. Moreover, Knight et al.'s study (2014) suggested that associate's degree earners were on average 29 years old by the time they graduated with a bachelor's degree in engineering. Explanations for the differences in ages, in part, can be attributed to economic factors. Brawner and Mobley's (2014) qualitative study found that economics was critical in an engineering transfer student's decision to return to higher education, choice of institution, and determination to delay graduation by participating in co-op or internship opportunities.

Financial need was found to negatively influence the persistence for this population of students (Costentino et al., 2014). Engineering students in one study indicated that financial factors such as the cost of a four-year institution, lack of financial aid, and balancing work, school and family responsibilities were the most challenging obstacle in transferring (Blash et al., 2012). Several studies suggest that receipt of scholarship was related to increasing engineering transfer student persistence (Anderson et al., 2011; Anderson-Rowland, 2011; Anderson-Rowland, 2009; Didion, 2015). Of the studies referenced, most scholarships were science, technology, engineering, and math (S-STEM) scholarships sponsored by the National Science Foundation (NSF). The NSF S-STEM scholarships range from $250 to full tuition for two years at two-year institutions and four years at four-year institutions. In addition, Anderson et al. (2011) found that receipt of a scholarship was significantly related to the number of hours worked per week among engineering transfer students. Specifically, students who were awarded larger scholarships worked fewer hours per week. Scholarships and decreased number of hours worked per week are critical factors for STEM transfer students. A significant portion of transfer students work 20 or more hours per week, which has been shown to negatively impact their academic success (Anderson et al., 2011; Smith & Van Aken, 2020).

Increasing understanding of vertical transfer students pursing advanced engineering degrees, and specifically focusing on similarities and differences across demographic backgrounds is imperative so that administrators, educators, and college personnel can improve the recruitment, support, and retention efforts through this pathway. The community college to four-year institution pathway can be one way to increase parity in this predominantly White, male-dominated profession. Additionally, researchers must investigate how age and financial need act as either independent or interacting factors that impact time to graduation and academic success for this population of students.

Pre-Transfer Academics

Pre-transfer academics denotes the academic performance of a vertical transfer student prior to enrolling at the four-year institution. Academic performance can be described by the number of transfer credit hours, associate's degree attainment, transfer of math credit/remedial math completed, and grade point average (GPA) at the sending institution. Several studies found that increased community college credit earned was related to higher academic performance at the receiving institution (Anderson-Rowland et al., 2015; Lakin & Cardenas Elliot, 2016; Lopez & Jones, 2017). Other research studies found that students who earned an associate's degree before their transfer had higher rates baccalaureate degree attainment (Lee & Schneider, 2016; Lopez, 2012; Mattis & Sislin, 2005). Interestingly, in a qualitative study with Cal-PASS, post-transfer student focus groups indicated that students did not perceive that an associate degree held value for the two-year to four-year pathway. Overall community college GPA was a strong predictor of persistence in engineering (Anderson-Rowland, 2011; Lakin & Cardenas Elliot, 2016; Lopez & Jones, 2017; Shields & Pietroburgo, 2000). GPA in core engineering community college courses also predicted persistence (Shields & Pietroburgo, 2000).

Post-Transfer Academics

The academic performance of transfer students following their transition to a four-year institution is defined as post-transfer academics. Multiple studies have suggested that the number attempted credit hours during the first semester, specifically attempting fewer credit hours, at the receiving institution is related to higher persistence rates for this population (Anderson-Rowland, 2009; Laier & Steadman, 2014; Lakin & Cardenas Elliot, 2016; Laugerman & Shelley, 2013). Additionally, multiple authors found increased transfer student persistence as the first semester GPA increased (Laugerman & Shelley, 2013; Laugerman et al., 2015). Moreover, the first semester GPA at the receiving institution is commonly associated with "transfer shock," which is the tendency of transfer students to experience an initial drop in GPA during the first semester at the receiving institution (Hills, 1965). Most engineering transfer students (i.e., vertical or lateral) experience some level of transfer shock (Anderson-Rowland, 2011; Smith et al., 2021). However, vertical transfer students were discovered to experience higher levels of transfer shock and were more likely to leave the receiving institution (Lakin & Cardenas Elliot, 2016).

Following Hills' observation on this phenomenon with transfer students, scholars have expanded the meaning of transfer shock to include various institutional, academic, and social barriers related with the experience of transfer students during their first semester at the receiving institution (Laanan, 2007; Townsend et al., 2006). Though the transfer experience is similar for FTFY students and first-year transfer students, there is evidence that research-intensive institutions treat these two student populations differently (Eggleston & Laanan, 2002; Fematt et al., 2021). Furthermore, despite research demonstrating the evidence and impact of transfer shock, few studies have been devoted to understanding the student and institutional factors that contribute to the drop in first semester GPA that engineering transfer students experience (Lakin & Cardenas Elliot, 2016).

An additional limitation identified in this body of literature was the lack of research examining academic performance-based factors after the first post-transfer academic year. Understanding the relationship between academic performance past the first year of transfer and persistence can provide researchers, practitioners, and higher education administrators further insight into how to increase engineering transfer students' long-term academic success.

Institution-Influenced Factors of Persistence

The following is a synthesis of recent literature which is concentrates on the institutional environment at four-year institutions, specifically in the departments or colleges where engineering programming is located. In addition, institution-influenced factors are based on engineering department environment and transfer-specific support services. In alignment with these focus areas, the following summarizes results from relevant empirical studies. It identifies areas to advance our understanding of the institutional factors that promote or detract from the persistence of engineering transfer students.

Institution Characteristics

Institutional characteristics that include institutional type, class size, and faculty makeup with community colleges are related to student integration and subsequent persistence of engineering transfer students. Community colleges tend to offer smaller class sizes that allow students to have more individualized attention and more one-on-one interactions with faculty (Bryant, 2001; Crisp & Mina, 2012). Significant differences in students' academic integration have been observed between community colleges and two-year institutions (Evans & Mody-Pan, 2010). Transfer STEM students from Evans and Mody-Pan's study (2010) reported feeling that their community college instructors cared more and were more comfortable attending office hours than the faculty at their four-year institution. One reason for this disparity may be that many undergraduate classes are held in large lecture halls at large research-intensive universities, limit opportunities for faculty and peer interactions (Fematt et al., 2021). Large classroom settings may be overwhelming which can suppress faculty and peer interactions and participation (Fematt et al., 2021; Roberts & McNeese, 2010; Townsend et al., 2006). Broader research on transfer students has found that this population of students has fewer interactions with faculty, which an issue since students who report having positive faculty relationships indicate having higher levels of engagement and academic success (Astin, 1993; Fematt et al., 2021; Woods & Williams, 2013). One reason for fewer interactions may be that transfer students often describe faculty at four-year institutions to be unavailable or unresponsive when they are approached for academic assistance (Townsend & Wilson, 2006). Additionally, faculty behaviors and attitudes at four-year institutions may be rooted in their belief that it is a student's responsibility to rectify academic deficiencies (Fematt et al., 2021). In contrast, faculty at two-year institutions are more likely to aid students with their learning and development (Townsend & Wilson, 2008).

The variation in faculty and student expectations in the classroom may be attributed to transfer students not fully understanding the difference between research-oriented institutions and applied-oriented institutions (i.e., community colleges) (Townsend & Wilson, 2008). For example, tenure-track faculty at the research-intensive institutions earn promotion and tenure through research, publications, and funding procurement instead of teaching. In contrast, most community college instructors earn promotion through teaching and time served (Townsend & Wilson, 2008). Missouri S&T, a land-grant institution, realizes that transfer students contribute both revenue and diversity to their campus and has included goals for transfer students in the university's strategic plan. The university's noted connection of the value of engineering transfer students to the strategic plan of the university assists in maintaining strong support- including among faculty- for transfer students (Didion, 2015). Another way to address the issue of conflicting expectations between students and faculty is to inform prospective engineering transfer students of the expectations of the four-year institution and how the institution's mission will shape their overall experience (Fematt et al., 2021; Wawrzynski & Sedlacek, 2003).

Institutional Environment

Institutional environment plays an essential role in the persistence of transfer students pursuing undergraduate engineering degrees (Townley et al., 2013). The results of Townley et al.'s (2013) study suggest that engineering transfer students place greater importance on the sense of community at their receiving institution than the community college they attended. Their sense of community impacts students' social integration as they interact with the campus environment (Darrow, 2012). Due to the strict course requirements for engineering students, most students interact with the campus environment directly through their engagement in engineering courses and peer and faculty interactions. Therefore, a supportive College of Engineering or Engineering Department promotes increased involvement in social activities and student integration with faculty and peers (Smith & Van Aken, 2020). Moreover, several studies have found that supportive engineering departments that have peer and faculty mentoring programs specifically for transfer students has been shown to increase persistence and satisfaction for minoritized students (Allen & Zhang, 2016; Anderson-Rowland, 2011; Jackson et al., 2013; Jefferson et al., 2013; Olson et al. 2016; Sheinberg, 2015;).

Positive relationships with engineering faculty members have been linked to differences in engineering-degree attainment of minoritized transfer students in undergraduate programs

(Dika et al., 2020; Palmer et al., 2012). Students who create meaningful connections with faculty members outside of the classroom reported higher levels of college satisfaction and persistence to graduation (Cole & Espinoza, 2008). In addition, minoritized students who persisted to degree completion emphasized the instrumental role of faculty members in their academic success (Cole & Espinoza, 2008). While research has highlighted the importance of minoritized students having faculty role models from similar cultural and ethnic backgrounds (Museus & Liverman, 2010; Suitts, 2003; Lent et al., 2005), undergraduate engineering programs typically lack underrepresented minority faculty members. However, white faculty members can make meaningful connections and play a vital role in underrepresented minorities students' success at predominantly white institutions (PWIs) (Palmer et al., 2012). Latino students in Cole and Espinoza's study (2008) reported that having supportive and accessible engineering professors regardless of their ethnicity was a factor in their academic success.

Academic Advising for Transfer Students

Academic advising refers to the academic guidance provided to students from the start of their transition to the receiving institution and continues until degree attainment in higher education (NACADA, 2017). Advising for transfer students often begins with an orientation to the university and academic advising for their selected engineering major. For example, Grites (2014) contends that transfer students require "an orientation to the culture of the new campus, the academic and social impacts of the new environment, the academic advising structure, and the support services, activities, and organizations available to them" (p. 126). Further, researchers have discussed the importance of academic advising during transfer-focused orientations for engineering students (Anderson-Rowland, 2011; Mobley & Brawner, 2014).

However, more energy and resources are typically devoted to orientation programs for full-time, first-year students compared to transfer students by receiving institutions.

Multiple authors have described specialized academic advising as having a dedicated advisor or team of advisors for transfer students (Jones & Waggenspack, 2015; Laier & Steadman, 2014). Specialized academic advising that provides accurate and timely information about transfer credits, academic plans of study, progress toward a degree, and academic requirements at receiving institutions is vital for engineering transfer student success and persistence (Sarder, 2013; Scott et al., 2017; Skurla et al., 2013). Specifically, a review of midterm grades and intrusive advising interventions for engineering transfer students who are not meeting program requirements were found to positively influence persistence (Sarder, 2013; Scott et al., 2017). Some researchers have recommended that institutions go a step further and create centrally located advising centers (Anderson-Rowland, 2011).

Specialized transfer advising and transfer-specific orientation were the most cited institution-influenced factors in a student's persistence in engineering (Smith & Van Aken, 2020). These factors indicate that it is the sending institution's responsibility to provide customized support services to increase the persistence of engineering transfer students (Smith & Van Aken, 2020). These services, along with peer and faculty mentoring, are critical elements for engineering programs to consider to create a supportive college or department environment for engineering transfer students.

Student-Influenced and Institution-Influenced Factors

Some factors that were found to impact transfer student persistence can be categorized as both student-influenced and institution-influenced. For example, a student's first semester credit hours post-transfer can be influenced by the amount or type of transfer credits earned pre-transfer and by recommendations made by the student's academic advisor at the receiving institution. The interaction between student- and institution-influenced factors points to the necessity of engineering colleges or departments to have transfer-specific student support services. It is not enough for institutions to have student orientations, academic advising, or mentoring programs. Institutions must make efforts to create transfer-specific student services and programs as transfer students' needs and engagement contrast from FTFY engineering students (Allen & Zhang, 2016; Anderson-Rowland, 2011). A gap in current literature is how context shapes individual factor influence. In other words, understanding the interaction component between student-influenced and institution-influenced factors. Most studies focus on student-influenced or institution-influenced factors, with very few considering them together (Smith & Van Aken, 2020).

Smith and Van Aken (2020) summarized the studies that did consider the interaction between student-influenced and institution-influenced factors into the following perspectives:

1. Post-transfer academics were found to be factors affecting the persistence of engineering transfer students. However, post-transfer academics have been found to be influenced by student's pre-transfer academics. For example, the number of engineering classes completed and the grades in those courses affected the coursework completed post-transfer (p. 873).
2. A student's motivation was found to be influenced by the institutional culture and by academic advising at the receiving institution. A negative experience at the receiving institution could impact the student's motivation level and has shown to result in attrition. Conversely, positive experience could influence the student's drive to persist. (p. 873).

These findings suggest that future studies consider the interaction between student-influenced and institution-influenced factors to aid in understanding how to increase the persistence of this population.

Summary

This chapter provides a synthesis of relevant literature on vertical engineering transfer students related to this study. Findings highlight the importance of student demographics, financial need, pre- and post-transfer academic performance, institutional environment, specialized academic advising, transfer-specific orientation, and transfer-specific student support services for engineering transfer students. Moreover, these factors aid in our understanding of why vertical transfer students persist or not in engineering. This review of literature produced the following main conclusions on the persistence and academic success of engineering transfer students:

1. The vertical transfer pathway provides an opportunity to increase participation and diversity in the engineering workforce.
2. Theoretical frameworks have only been used in a quarter of research literature on engineering transfer students. There are limitations to previously used theoretical frameworks to understand the persistence of engineering transfer students, the main one being that all frameworks were developed with first-year full time students in mind. A more inclusive model is necessary to reflect the characteristics and experiences of engineering transfer students.
3. Advanced statistical methodologies have been underutilized by researchers in this field of study. Moreover, multi-institutional or state-level samples have been

underutilized to understand how higher education systems structures within states promote (or detract) from the persistence of engineering transfer students.

4. The pre-transfer preparation of engineering transfer students affects their persistence in four-year engineering programs.

5. Researchers have concluded that institutions must create a supportive culture that provides transfer-specific student support to this population of students.

6. The interaction between student and institutional factors that impact the persistence of engineering transfer students has been explored by very few researchers.

These themes have implications for the present study on engineering transfer students. One of the goals of the present study is to provide evidence to address these gaps in literature by using a longitudinal state-level database to investigate how the interaction between student characteristics and institutional factors influences the academic success and persistence of this population at multiple public institutions. The following chapter explains these methods and the background of the study in greater detail.

CHAPTER 3: METHODOLOGY

This study examined the influence of student characteristics, academic factors, and institutional factors on the academic success and persistence of engineering transfer students who transferred from two-year institutions to four-year institutions in North Carolina from 2009 to 2016. The predictors of Bachelor of Engineering degrees for this unique student population were examined using advanced statistical methods through the lens of Smith and Van Aken's (2020) Engineering Transfer Student Persistence conceptual framework. A secondary data analysis using a non-experimental correlational, quantitative research design was utilized to examine the influence of student-influenced and institution-influenced factors on the academic success and persistence of vertical transfer students pursuing baccalaureate engineering degrees. This chapter identifies and describes the research questions, setting, sample, data source, research design, analytic approach, and measures.

Research Questions

This study utilized regression analyses to investigate student, academic, and college of engineering/department of engineering factors associated with the academic success and bachelor's engineering degree attainment of students who transferred to four-year institutions from two-year institutions. Semester GPA was selected as a measure of academic success in the first semester at the receiving institution since it is the most commonly used measure of academic success in educational research and assessment (York et al., 2015). While there has been debate in recent years about the utility of using GPA an indicator of academic success, the GPA requirements for engineering students to maintain eligibility to continue in the college/department of engineering after the first-term remains strict. Multiple regression analysis was used to investigate the relationship between student-influenced and institutional-influenced factors and academic success during the first semester post-transfer, whereas logistic regression was used to examine the relationship between student-influenced and institution-influenced factors and persistence. The first research question was addressed using multiple linear regression to examine the extent to which student backgrounds and pre-transfer academics, institutional characteristics, and post-transfer attempted and earned credit hours predict the academic success of transfer engineering students in their first semester post-transfer. The second research question was addressed using multiple linear regression to examine how institution-influenced characteristics moderate the effect of pre-transfer academics on academic success after the first term post-transfer. The third research question was addressed using logistic regression to examine the extent to which student backgrounds and pre-transfer academics, institutional characteristics, and post-transfer academics predict the baccalaureate degree attainment of transfer engineering students. Lastly, the fourth research question was addressed using logistic regression to examine the extent to which institutional characteristics moderate the effect of post-transfer academics on baccalaureate degree attainment.

1. *How do student and institutional factors predict the academic success of engineering transfer students in their first term at the receiving institution?*
2. *How do institution-influenced factors moderate the relationship between pre-transfer academic factors and the academic success of engineering transfer students during their first term at the receiving institution?*
3. *How do student and institutional factors predict baccalaureate engineering degree attainment of transfer students?*
4. *How do institution-influenced factors moderate the relationship between post-transfer academic factors and baccalaureate engineering degree attainment?*

Methods

The research examined transfer data of NC community college 4,163 students who entered universities within the University of North Carolina (UNC) System to pursue a baccalaureate degree in engineering. The public universities included North Carolina Agricultural and Technical State University (NC A&T), East Carolina University (ECU), North Carolina State University (NC State), the University of North Carolina at Charlotte (Charlotte), and Western Carolina University (WCU) from 2009 to 2016. Student data were obtained from a UNC System transfer student dataset made available to the researcher through NC State's Belk Center for Community College Leadership and Research. In addition, the researcher received institutional data through each university's office for institutional research and the college/department of engineering and the Carnegie Classification of Institutes for Higher Education. Table 3 summarizes the basic classification, undergraduate profile, and size and setting for each receiving university as reported by the Carnegie Classification of Institutes for Higher Education in 2018. However, the Basic Classification and Selectivity of several institutions changed during the 2009 to 2016. For example, Charlotte's Basic Classification changed from Doctoral University to Doctoral University- High Research activity in 2016.

Table 3

Summary Table of Receiving Institutions

Institution	Basic Classification	Undergraduate Profile	Size and Setting
NC A&T[a]	Doctoral University: High Research Activity	Four-year, full-time, inclusive, higher transfer-in	Large, primarily residential
ECU	Doctoral University: High Research Activity	Four-year, full-time, selective, higher transfer-in	Large, primarily residential
NC State	Doctoral University: Very High Research Activity	Four-year, full-time, more selective, higher transfer-in	Large, primarily residential
Charlotte	Doctoral University: High Research Activity	Four-year, full-time, selective, higher transfer-in	Large, primarily residential

Table 3 continued

WCU	Master's Colleges & Universities: Larger Programs	Four-year, full-time, selective, higher transfer-in	Medium, primarily residential

[a] Historically Black Colleges and Universities (HBCU)

Data Sources

Student data were obtained from the UNC System longitudinal transfer student dataset. The transfer student dataset included the classification of instructional programs (CIP) codes as designed by the Institute for Education Statistics (IES) National Center for Education Statistics (NCES) for each student. Only students whose primary major was listed as engineering (CIP 14) or engineering technology (CIP 15) throughout their time at the receiving institution were included in the regression analyses since the focus on the study is on persistence in engineering. However, students who started as an engineering or engineering technology major and switched to a major outside of engineering were tracked and were included in the descriptive results. Students who were admitted to the receiving institution before 2009 or after 2016 were omitted. The dataset included students who were admitted after 2016; however, only students who were allowed a minimum of eight semesters at the receiving institution were included. Finally, only students who transferred from a community college to four-year institutions within the UNC System that offered baccalaureate engineering degrees were included since the focus of the study is on vertical transfer students.

The researcher first contacted the Associate Provost for Institutional Research at Charlotte to request the institutional characteristics data for Charlotte. It was explained that the institutional research offices at each institution would be able to provide the faculty, enrollment, and average class size data, but the college/department of engineering at each institution would need to provide data on student support services, orientation, and advising. The Associate

Provost provided a contact for institutional research offices at each institution. Next, the researcher emailed each contact and explained purpose of the study, provided a spreadsheet of the requested data and the Non-Human Subjects Research letter. Institutional data that included yearly faculty demographics, total enrollment in the college/department of engineering, and average engineering class size from 2009 to 2019 were obtained via email from each contact. Also, each contact provided a name of an administrator in the college/department of engineering to request the remaining institutional data.

At WCU, ECU, and Charlotte, the college/department of engineering includes engineering and engineering technology majors. At NC A&T, engineering and engineering technology majors are in separate colleges, so only the College of Engineering and therefore only engineering majors are included. The institutions reported data from the fall census for each year. Faculty demographics included the count of male and female faculty and the count of race/ethnicity per the IPEDS reporting categories. Student enrollment included the total number of undergraduate students in the college/department of engineering as reported in each university’s fact book and contains an enrollment headcount for first and second majors. Average undergraduate engineering class sizes were reported and included laboratory, lecture, seminar, and lecture and laboratory formats. Independent study courses, internships, practicums, and other similar courses were excluded by the institutions.

Institutional data on transfer student support services offered to students were obtained by college/department of engineering administrators at each receiving institution. The researcher emailed each administrator and explained purpose of the study, provided a spreadsheet of the requested data and the Non-Human Subjects Research letter. Administrators reported whether a transfer-focused orientation and transfer-specialized advising were provided by the college/department of engineering specifically to engineering transfer students from 2009 to 2019. Institutional data for 2020 was not included in this study. College/department of engineering administrators also reported if articulation agreements between community colleges and the institution existed from 2009 to 2019. All receiving institutions indicated that there were formal articulation agreements in place with community colleges.

Outcome Variables

This study includes two outcome variables: *First-Term GPA* and *Degree Completion.* Semester GPA The *First-Term GPA* variable measures a transfer student's academic success post-transfer. *First-Term GPA* ranged from 0.00 to 4.33. NC State allows for a maximum GPA of 4.33 while the other institutions have a maximum GPA of 4.0. The *Degree Completion* variable measures a transfer student's persistence in engineering. The *Degree Completion* outcome variable is a categorical variable and indicates whether the student graduated with a baccalaureate engineering degree or other baccalaureate degree from one of the five public universities that offer undergraduate engineering degrees in North Carolina.

Student-Influenced Predictors

Student-influenced variables included student demographic characteristics and pre-transfer academics. *Sex* is defined as male or female, there were no incidence of other sexes or genders in the dataset, and *Age* is the approximate age of the student given a specific academic year by calculating the academic year from the student's date of birth. The *Age* variable was aggregated into two categories: below 23 and above 24 per NCES's (2020) definition of traditional and non-traditional students. The *Race* variable includes the nine IPEDS Race/Ethnicity categories: non-resident alien, race and ethnicity unknown, Hispanics of any race, American Indian or Alaskan Native, Asian, Black or African American, Native Hawaiian or

Other Pacific Islander, White, and two or more races. Black or African American, Hispanics of any race, White, Asian, and Other Race are the races/ethnicities used in the model and were operationally recorded (i.e., dummy coded). Due to the low levels of participation in engineering programs by some marginalized groups (i.e., n < 30), *Other Race* was created by combining all race categories other than Black or African American, Hispanics of any race, White, and Asian into a single category. *Pell* is a dichotomous variable that indicates whether a student was ever awarded a Federal Pell Grant (i.e., 0= no Pell Grant awarded, 1= Pell Grant awarded). Pell Grant is used as an indicator of the student's socioeconomic status. *Type of Engineering Major* is a dichotomous variable that indicates whether a student was an engineering major or engineering technology student.

Pre-transfer academics included the number of applied transfer credit hours and associate degree award. The number of transfer credit hours applied to the baccalaureate degree upon entry at the receiving institution was denoted as *Applied Transfer Hours.* The predictor *Associate Degree* indicated any post-secondary awards including Associate of Science, Associate of Applied Science, Associate of Arts, and Associate of General Education before or during the year that the student enrolled at the receiving institution. The associate degrees were operationally recorded to 0= no associate degree earned, 1= Associate of Arts, Fine Arts, or General Education earned, 2= Associate of Applied Science, and 3= Associate of Science.

Institution-Influenced Predictors

Institution-influenced variables include both characteristics of the College of Engineering or Department of Engineering and the university as classified by the Carnegie Classification for Institutions of Higher Education. *Female Faculty* is the percentage of female engineering faculty members. *URM Faculty* represents the percentage of underrepresented racial/ethnic faculty members (i.e., Black or African American, Hispanic, and American Indian or Alaskan Native) within the college/department of engineering. While Asian faculty members are minoritized in the United States, they are overrepresented in engineering faculty positions compared to the percentage of Asian population. *Transfer-Focused Orientation* denotes whether the college/department of engineering offered a transfer-focused orientation to students. *Transfer-Specialized Advising* denotes whether the college/department of engineering had dedicated advisor(s) assigned to transfer students.

The Carnegie Classification of Institutes of Higher Education was used to determine *Basic Classification* and *Selectivity Classification* for each of the five receiving universities. The 2010, 2015, and 2018 editions of the classifications were used in determining the university characteristics at the time of the student's entry into the receiving institution. *Basic Classification* was ranked from Master's College and Universities to Doctoral University with very high research activity. None of the receiving institutions were rated as Baccalaureate Colleges, so the ranking was not included in the study. Master's Colleges and Universities are defined as institutions that awarded at least 50 master's degrees and fewer than 20 doctoral degrees during the update year and include designations for small, medium, and large programs. Doctoral Universities are institutions that awarded at least 20 research/scholarship doctoral degrees or below 20 research/scholarship doctoral degrees that awarded at least 30 professional practice doctoral degrees in at least two programs at the time of update. The Doctoral Universities' classification includes designations for high and very high research depending on total research expenditures (a minimum of $5 million) as reported by NSF Higher Education Research and Development Survey (HERD).

The *Selectivity Classification* was ranked from inclusive to very selective and is determined by first-year students' standardized test results. Inclusive institutions were characterized as institutions that either did not report test score data or scores indicating that the institutions extend admission to a wide range of first-year students concerning academic preparation and achievement. Selective institutions were characterized as selective in admissions and ranked 40th to 80th percentile of selectivity amount all baccalaureate institutions. Very selective institutions were described as more selective and ranked 80th to 100th percentile of selectivity among all baccalaureate institutions.

Student-Influenced and Institution-Influenced Predictors

Predictors that were considered were influenced by both student and institution factors included the variables related to post-transfer academics. They included: *School*, *Year of Transfer, Total Semesters, First-Term Attempted Hours, First-Term Earned Hours, Total Attempted Hours at Institution, Total Earned Hours at Institution, Cumulative GPA,* and *Cumulative Hours Earned in Higher Education.* The *School* variable indicates which of the five UNC System institutions the student transferred to, and the *Year of Transfer* variable corresponds to the academic year that the student transferred to the receiving institution. Thus, the *School* and *Year of Transfer* variables capture potential unobservable predictors not in the model that are related to the year of entry and receiving institution.

Total Semesters refers to the total number of fall and spring semesters that the student was enrolled at the receiving institution. *First-Term Attempted Hours* denotes the student's attempted credit hours, and *First-Term Earned Hours* indicate the student's earned credit hours during the first-semester post-transfer. *Total Earned Hours at Institution* denotes the total number of credit hours earned by the student at the receiving institution. *Cumulative GPA* represents the student's grade point average at the receiving institution during the last semester recorded and ranged from 0.00 to 4.33. NC State was the only institution that allowed for GPAs to be above 4.00. The predictor *Cumulative Hours Earned* indicates the total number of credit hours that a student earned prior to transfer and at the receiving institution. This value is the sum of the *Applied Transfer Hours*, and *Total Earned Hours at Institution* variables.

All predictor variables were selected based on the literature and available data. Table 4 provides the names, descriptions, and coding for each variable in the study.

Table 4

List and Description of Variables in Model

Variable Name	Variable Type	Description
Outcome Variables		
First-term GPA	Continuous	Measured on a 0.00 to 4.33 scale
Degree Completion	Categorical	0= no baccalaureate engineering degree earned 1= baccalaureate engineering/engineering tech. degree earned; 2= other baccalaureate degree earned
Student-Influenced Predictors		
Sex	Categorical	Dummy coded: 0= male, 1= female
Race	Categorical	Dummy coded: 1=Black, 2=Hispanic, 3=Other, 4=Asian, 5=White*
Age	Dichotomous	Calculated based on birthyear and academic year at entry; aggregated to 0= below 23, 1= above 24
Pell	Categorical	Dummy coded: 0= no Pell Grant awarded, 1= Pell Grant awarded
Type of Engineering Major	Dichotomous	Dummy coded: 0= engineering technology, 1=engineering
<u>Pre-Transfer Academics:</u>		
Applied Transfer Hours	Continuous	Measured in credit hours
Associate Degree	Categorical	Dummy coded: 0= no associate degree earned*, 1= Associate of Arts, Fine Arts, or General Education earned, 2= Associate of Applied Science, 3= Associate of Science
Institution-Influenced Predictors		
Female Faculty	Continuous	Percentage of COE/DOE faculty identifying as female
URM Faculty	Continuous	Percentage of COE/DOE faculty identifying with underrepresented racial/ethnic group
Basic Classification	Categorical	Dummy coded: 1=Master's College and Universities, 2= Doctoral University, 3=Doctoral University- High Research, 4= Doctoral University- Very High Research*
Selectivity Classification	Categorical	Dummy coded:1=inclusive*, 2= selective, 3= more selective
Average Class Size	Continuous	

Table 4 continued

Variable Name	Variable Type	Description
Transfer-Focused Orientation	Dichotomous	0= no transfer-focused for transfer students 1= transfer-focused orientation offered to transfer students
Transfer-Specialized Advising	Dichotomous	0= no transfer-specialized advising 1= transfer-specialized advising
Predictors Influenced by Both Student and Institution		
School[a]	Categorical	Dummy coded: 1= NC A&T, 2=ECU, 3=NC State, 4= Charlotte*, 5=WCU
Year of Entry[b]	Interval	Academic year that student started at receiving institution
Post-Transfer Academics First-Term:		
First-Term Attempted Hours	Continuous	Measured in credit hours attempted during first term
First-Term Earned Hours	Continuous	Measured in credit hours earned during first term
Post-Transfer Academics All-Terms:		
Total Semesters	Continuous	Measured in total number of spring and fall semesters from entry
Cumulative GPA	Continuous	Measured on a 0.00 to 4.33 scale
Total Earned Hours	Continuous	Measured in total number of earned credit hours at receiving institution
Cumulative Hours Earned in Higher Education	Continuous	Measured by sum of transfer credit hours and total number of earned credit hours

[a] indicates reference group after dummy coding
[b] variables to potentially capture unobservable predictors not in the model

Analytic Approach

Descriptive and inferential statistical analyses were conducted on the student and institutional data to understand the factors that impact students' academic success in the first-semester post-transfer and their persistence in pursuing baccalaureate engineering degrees. For research questions regarding the academic success of the transfer students in their first semester, multiple regression analysis (with blocked entry methods) was conducted that consisted of three blocks aligned with Smith and Van Aken's (2020) Engineering Transfer Student Persistence conceptual framework. Student-influenced predictors were included in the first block, institution-influenced predictors in the second block, and predictors that are influenced by both student and institution factors in the third block.

For the research questions regarding engineering transfer student persistence, logistic regression analysis was used. Using a dichotomous outcome of baccalaureate engineering degree attainment as a measure of persistence, variables from the three categories outlined in Smith and Van Aken's framework were utilized to create a logistic regression model to examine predictors of baccalaureate degree completion. The three categories of predictor variables that align with Smith and Van Aken's (2020) Engineering Transfer Student Persistence conceptual framework was entered into the model by blocks as described previously. Table 5 provides a summary of the research questions and analysis methods to be used for each question.

Table 5

Summary of Research Questions and Analytic Methods

Research Questions	Predictor Block(s)	Outcome	Analyses
Q1: How do student and institutional factors predict the academic success of engineering transfer students in their first term at the receiving institution?	Student-Influenced Institution-Influenced Factors Influenced by Both (First-Term only)	1st term GPA at receiving Institution	Multiple Regression, Descriptive Statistics
Q2: How do institution-influenced factors moderate the relationship between pre-transfer academic factors and the academic success of engineering transfer students during their first term at the receiving institution?	Student-Influenced Institution-Influenced Factors Influenced by Both (First-Term only) Interaction of Institution-Influenced x Pre-Transfer Academics	1st term GPA at receiving Institution	Multiple Regression, Descriptive Statistics
Q3: How do student and institutional factors predict baccalaureate engineering degree attainment of transfer students?	Student-Influenced Institution-Influenced Factors Influenced by Both (All Terms)	Bachelor engineering degree attainment	Logistic Regression, Descriptive Statistics
Q4: How do institution-influenced factors moderate the relationship between post-transfer academic factors and baccalaureate engineering degree attainment?	Student-Influenced Institution-Influenced Factors Influenced by Both (All-Terms) Interaction of Institution-Influenced x Post-Transfer Academics	Bachelor engineering degree attainment	Logistic Regression, Descriptive Statistics

Data Screening and Assumptions

Data were screened before analysis in SPSS 26 (2019) to test assumptions related to univariate and multivariate statistical techniques. Missing values were found for institution-influenced and post-transfer academic predictors.   The missing values combined represented 1.1% of the overall sample. Therefore, the listwise deletion method to eliminate cases with missing data was used since the missing data is less than 5% of the overall sample (Tabachnick et al., 2012). The key assumptions of multiple linear regression, which include (a) normality of residuals, (b) independence, (c) nonconstant error of variance, (d) linearity, and (e) no multicollinearity, were addressed prior to analysis of research questions 1 and 2 (Hahs-Vaughn, 2016).   For research questions 3 and 4, the key assumptions associated with logistic regression were addressed, which include (a) independence of observations, (b) dependent variable is binary, (c) no multicollinearity, (d) linearity, and (e) no outliers, high leverage values, or highly influential points (Hahs-Vaughn., 2016).

Descriptive Statistical Analysis

Descriptive statistics were examined, including frequencies for categorical variables and means and standard deviations for continuous variables. Specifically, frequency distributions, means, and standard deviations of the predictor variables on the *First-Term GPA* outcome variable are included. Additionally, the descriptive statistics for the five UNC System universities' characteristics were computed by the outcome variables, *First-Term GPA* and *Degree Completion.* Descriptive statistics are provided for students who did not earn a baccalaureate degree, earned an engineering or engineering technology degree, and earned other type of baccalaureate degree. These analyses provide general information on the students' background characteristics, pre-transfer academic performance, post-transfer performance, and institutional characteristics experienced by vertical transfer students who pursued baccalaureate engineering degrees at the five UNC System universities. In addition, descriptive statistical analysis assisted to check for data quality.

Multiple Linear Regression

Before running the multiple regression analyses to address research questions 1 and 2, the data were screened and checked for assumptions. Review of the histogram and normal probability plot (P-P) of regression standardized residual indicated that the residuals were normally distributed. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.612. The variation inflation factors (VIFs) indicated that the no-multicollinearity assumption was violated (VIF>5) for the dummy coded variables *Selectivity Classification-Inclusive* (VIF=140.0), *Transfer-Focused Orientation* (VIF=26.5), and *Transfer-Specialized Advising* (VIF=21.4); and for the continuous variables *Average Class Size* (VIF=13.7) and *URM Faculty* (VIF=130.4).

To investigate the multicollinearity further, Pearson product moment correlations were generated to determine the strength and direction of relationships between the variables and as a check for multi-collinearity. The correlations matrices were generated for each block. Evidence of highly correlated variables was found in the institution-influenced block. *Inclusive* was highly correlated (r=.962) with *URM Faculty*. These findings were expected due to NC A&T having inclusive undergraduate admissions and the highest percentage of URM faculty. Additionally, *More Selective* was highly correlated with *Doctoral University- Very High Research* (r=.721). There was a perfect positive correlation (r=1.000) between *Advising* and *Doctoral University-Very High Research*. NC State which is classified as a doctoral university with very high research was the only institution that indicated that there are transfer-specialized advisors dedicated to only to transfer students. A less intuitive finding was the correlation between *Female Faculty* and *Orientation* (r=.730) and between Average Class Size and Doctoral University-Very High Research (r= .740). A closer look found that institutions that held transfer-focused orientations had a lower percentage of female faculty.

Based on these results, the dummy coded *Basic Classification* and *Selectivity Classification* variables, and the *Orientation Variable* were removed from the final regression model. The *URM Faculty*, *Female Faculty*, and *Average Class Size* variables was retained in the model since it provided a richer description of the college/department of engineering teaching environment at the receiving institutions. With the removal of these variables, the VIFs for the retained predictor variables were all under 3.7.

There was evidence of nonconstant variance of the regression errors, or heteroscedasticity. The outcome variable, *First-Term GPA*, had spikes at both ends of the GPA scale (i.e., very low GPA = 0.00, and very high GPA = 4.00). The extremes at the two ends of the measurement scale were deemed to be the primary reason for the nonconstant variance of regression errors. Further investigation did not find any data entry errors; therefore, the extreme GPAs were retained in the model. Additionally, these data were investigated to determine if the nonconstant variance was due to clustering of the institutions or cohort years. The residuals were plotted against both variables and the different mean residuals for the institutions and cohort years were centered at zero. Moreover, the variability between the receiving institutions and cohort years were similar. Therefore, it was concluded that clustering was not the cause of the nonconstant variance and that there was independence of errors.

Errors that are deemed heteroscedasticity can produce significant tests and confidence intervals that can be liberal or conservative (Hayes et al., 2007). A larger sampling variance can invalidate statistical inferences (Hayes et., 2007). To reduce the effects of the nonconstant variance of regression errors, heteroscedastic-consistent standard errors (HCSE) of the ordinary least squares (OLS) regression parameter estimates were utilized (Long et al., 2000). A review of Cook's Distance values greater than 4/n, or 0.0096, found 200 influential data points. To retain the data points, HC4 was deemed to be the most appropriate estimator of the errors. HC4 was derived by Cribari-Neto (2004) and was intended to take large leverage values and non-normal errors into consideration. The equation for HC4 is provided in (1).

$$HC4 = (X'X)^{-1}X'\text{diag}\left[\frac{e_i{}^2}{(1-h_{ii})^{\delta^i}}\right]X(X'X)^{-1}\text{ , where } \delta_i = \min\left\{4,\ \frac{nh_{ii}}{p+1}\right\} \quad (1)$$

Following a review of the assumptions, OLS multiple linear regression with the HCSE estimator was conducted to answer research question 1. Multiple linear regression is a statistical method that finds the line of best fit from a set of data with an outcome variable and one or more predictor variables. Specifically, multiple linear regression is used to examine the relationship between a set of predictors and an outcome measured on a continuous scale. Accordingly, this approach estimated the coefficient for the predictor variables that best predicts the value of the outcome variable, *First-Term GPA.* A general multiple linear regression model (Fox, 2008) is captured by (2), where y is the outcome variable (*First-Term GPA),* and β represents the regression coefficients that capture the relationships between the predictors and the outcome, *X* denotes the student-influenced predictor variables, and ε is a random error component:

$$y= \beta_0 + \beta_1(X_1) + \beta_2 (X_2) + \beta_3(X_3) +... + \beta_k(X_k) + \varepsilon \quad (2)$$

The predictor variables were grouped into three blocks that was added to the model simultaneously. Conceptually categorized variables involving student background and pre-transfer academics were added to Block 1. Block 2 estimated the effect of institutional factors, while Block 3 estimated the effect of post-transfer attempted and earned credit hours.

Prior to analysis of research question 2, the assumptions of multiple linear regression were addressed. The variation inflation factors (VIFs) for the predictor variables were all under 3.5 which indicated no multicollinearity. The assumption of normality of the assumptions was met following review of the normal distribution of the standardized residuals histogram and normal probability plot (P-P). The same issue of nonconstant variance of the regression of errors was evident. HC4 standard errors were utilized to address the issue of heteroscedastic errors. To address research question 2, the moderating effects of using interaction terms were included in the model in Block 4 to determine if the institution-influenced predictors moderated the relationship between pre-transfer credit hours predictors and *First-Term GPA*. The general equation for a model with two predictor variables and the interaction between the two predictors is represented by (3):

$$y = \beta_0 + \beta_1(X_1) + \beta_2(X_2) + \beta_{12}(X_1X_2) + \varepsilon \qquad (3)$$

The predictors were centered by subtracting the mean from each predictors original value before computing the interaction terms. This reduced multicollinearity among the predictors when the new interaction terms were included in the model.

Logistic Regression

The outcome variable, *Degree Completion,* was treated as a binary variable where 0= no engineering or engineering technology earned and 1= baccalaureate engineering or engineering technology degree earned. Before running the logistic regression analyses to address research questions 3 and 4, the data were screened and checked for assumptions. The dependent variable, *Degree Completion,* was investigated to verify that the assumptions of independence of observations and nominal were met. The variation inflation factors (VIFs) of the predictor variables indicated that the no-multicollinearity assumption was violated (VIF>5) for the variables *Total Earned Hours* (VIF=7.46) and *Cumulative Hours Earned in Higher Education* (VIF=7.33). The *Cumulative Hours Earned in Higher Education* is the sum of *Applied Transfer Hours* and *Total Earned Hours.* Therefore, *Total Earned Hours* and *Applied Transfer Hours* was retained in the model. Additionally, *First-Term Attempted Hours* and *First-Term Earned Hours* had VIFs close to 5 (VIF=4.95 and VIF=4.80). Therefore, only *First-Term Attempted Hours* was retained in the model.

There were seven standardized residuals with a value greater than 2.5 standard deviations. All data fell within expected ranges for GPA, percentages, and transfer hours; therefore, therefore, all cases were retained for further analysis. Linearity of the logit of *Degree Completion* and the continuous predictor variables was investigated by using the Box-Tidwell transformation in SPSS (Box & Tidwell, 1972). Predictor *Cumulative GPA* violated the assumption of linearity with a significant Box-Tidwell transformation (p=.005), but due to the large sample size, *Cumulative GPA,* was retained in the model (Hasan, 2020).

Logistic regression was then conducted to determine whether engineering or engineering technology baccalaureate degree could be predicted from student-influenced and institution-influenced predictors related to research questions 3 and 4. A logistic regression model was deemed appropriate since the outcome variable, *Degree Completion* is a binary indicator, and least-squares linear regression cannot yield the normally distributed error and constant variance (Hahs-Vaughn, 2016). The logistic regression equation allows the researcher to compute the probability that the outcome variable will occur. Changing the scale of the odds by taking the natural logarithm of the odds provides for the outcome variables to theoretically range from negative infinity to infinity (Hahs-Vaughn, 2016). The following general logistic regression model is captured by (4) where Y is the dichotomous outcome variable, β represents the regression coefficients that capture the relationships between the predictors and the outcome, and X denotes the student-influenced predictor variables.

$$\text{Logit}(Y) = \beta_o + \beta_1(X_1) + \beta_2(X_2) + \ldots + \beta_k(X_k) \quad (4)$$

To ease the interpretation, log odds was converted to a probability scale using (5) where the probability of baccalaureate engineering degree attainment was calculated with the following generic equation:

$$P(Y=1) = \frac{e^{\beta_o + \beta_1(X_1) + \beta_2(X_2) + \ldots + \beta_k(X_k)}}{1 + e^{\beta_o + \beta_1(X_1) + \beta_2(X_2) + \ldots + \beta_k(X_k)}} \quad (5)$$

where $P(Y=1)$ is the probability of baccalaureate degree attainment for predictors with values X.

In addition, to address Research Question 4, interaction effects were included in the model to determine if any institution-influenced predictors moderate the relationship between cumulative GPA and *Degree Completion.* Prior to analysis, the assumptions were checked with the addition of the interaction terms to the model. The variation inflation factors (VIFs) for the predictor variables were all under 3.1 which indicated no multicollinearity. To address Research Question 4, the moderating effects of using interaction terms were included in the model in Block 4 to determine if the institution-influenced predictors moderated the relationship between *Cumulative GPA* predictor and *Degree Completion*. The general equation for a logistic model with two predictor variables and the interaction between the two predictors is represented by (6):

$$\text{Logit}(Y) = \beta_0 + \beta_1(X_1) + \beta_2(X_2) + \beta_{12}(X_1X_2) + \varepsilon \quad (6)$$

The predictors were centered before computing the interaction terms.

Protection of Human Subjects

This study was submitted for IRB approval and was determined to be not human subjects research and did not require IRB approval. Student data was deidentified and given a unique identifier by the Belk Center for Community College Leadership and Research. The unique identifiers were not student ID numbers or social security numbers issued by the receiving institutions. The institutional research offices at each campus provided separate data for college/department of engineering gender and race/ethnicity. Further, the researcher aggregated the faculty demographic data separately such that minoritized faculty members could not be identified based on gender and race/ethnicity.

Summary

This correlational study utilized secondary, longitudinal data to examine the extent to which student characteristics, academic factors, and institutional characteristics predict the academic success and degree completion for students who transferred from a two-year institution to pursue a baccalaureate degree in engineering or engineering technology from NC A&T, ECU, NC State, UNC Charlotte, and WCU. This study also examined the moderating effects of institutional characteristics on the relationship between post-transfer credit hours and first-term GPA; and between post-transfer academics and baccalaureate degree completion. Based on the data structure, regression analysis was appropriate to examine the factors that predict the academic success and persistence of engineering transfer students in North Carolina.

This study utilized a modified version of the literature-based conceptual framework developed by Smith and Van Aken (2020) on the persistence of engineering transfer students, which organizes the predictors into three categories: student-influenced factors, institution-influenced factors, and factors influenced by both. The transfer student persistence outcome in Smith and Van Aken’s model is designated as baccalaureate engineering degree completion in this study. The variables included in this study were informed by a review of literature on engineering transfer student persistence, particularly the limited studies that utilized regression analyses to examine the degree completion of vertical transfer students (e.g., Cosentino et al., 2014; Lakin & Cardenas Elliot, 2016; Lee & Schneider, 2016; Lopez & Jones, 2017).

This study intended to examine the relationship between student demographics, academic performance, and institution characteristics predictors and the academic success and persistence of engineering students who transfer from two-year institutions. In addition, the study looked at how institutional characteristics (i.e., college/department of engineering faculty demographics and average class size, transfer-specific orientation, and university research and selectivity classifications) moderate the relationship between post-transfer academics and persistence. The study aims to illuminate practical and actionable findings that will aid four-year engineering institutions in increasing the academic success and persistence of vertical transfer students pursuing baccalaureate engineering degrees.

CHAPTER 4: RESULTS

The purpose of this study was to determine what student-influenced and institution-influenced factors predict academic success and persistence related to the vertical transfer of undergraduate engineering students in North Carolina. Specifically, this study aimed to uncover the influence of the contextual and climatic structure of the engineering department at the receiving institution (RI) on student academic outcomes over and above the influence of student background. This chapter provides the findings of this study, organized into three sections. The first section describes the characteristics of the engineering transfer students and the RIs included in this study. Frequencies and percentages are reported for each categorical or ordinal variable. Means and standard deviations are reported for each continuous variable. The second section presents the results for research questions 1 and 2 based on regression analysis. Lastly, the third section provides the results for research questions 3 and 4 based on logistic regression analysis.

Descriptive Statistics of the Sample and Variables

Demographic Backgrounds of the Sample

The demographic backgrounds of the 4,163 community college students who transferred to baccalaureate engineering programs in the UNC System from 2009 to 2016 is summarized in Table 6. Student demographics and background indicate that the transfer students in this study predominately identify as White (68.0%) and male (88.6%). Black or African American students accounted for 9.9% of the sample, and Hispanic or Latino, Asian, and Other students represented 6.6%, 5.3%, and 10.2%, respectively of the sample. The sample has a roughly equal representation of traditional (50.4%) and non-traditional (49.6%) age students, though the average age of the sample was 26 years old. Most of the sample included students who received a Pell Grant at the RI at 58.8%. The slight majority of vertical transfer students (53.6%) had earned an associate degree prior to transfer, where 30.9% had completed an Applied Associate of Science (AAS), and 15% had achieved an Associate of Science (AS). Lastly, the sample included slightly more engineering majors than engineering technology majors, 52.7% of engineering compared to 47.3% of engineering technology majors.

Table 6

Sociodemographic and Associate Degree Data for Vertical Transfer Students in Engineering

Variable	N	Frequency (%)
Gender		
Female	475	11.41
Male	3,688	88.59
Race/Ethnicity		
Black or African American	412	9.90
Hispanic or Latino	274	6.58
Other Race	426	10.23
Asian	221	5.31
White	2,830	67.98
Age		
23 or younger	2,098	50.40
24 and older	2,065	49.60
Pell Grant eligible		
No Pell Grant awarded	1,717	41.24
Pell Grant awarded	2,446	58.76
Associate degree awarded		
No associate degree earned	1,930	46.36
AA, AFA, or AGE earned	311	7.47
AAS earned	1,287	30.92
AS earned	635	15.01
Type of engineering major		
Engineering	2,193	52.68
Engineering Technology	1,970	47.32

Student Academic Characteristics

Table 7 shows the descriptive statistics of pre-transfer and post-transfer first-term academic predictor variables on the outcome variable for research questions 1 and 2, *First-Term GPA*. The average first-term GPA from the total sample was 2.71, with a standard deviation of

1.08. The kurtosis and skewness of the *First-Term GPA* variable are within +/- 1 indicated normal distribution (kurtosis= .10 and skewness= -.87). The GPAs were similar for male and female students. Disaggregated by major type, the average GPA was 0.23 points lower for engineering majors than engineering technology majors. Disaggregated by race, the mean first-term GPA for Black or African American transfer students was 0.37 points lower than White transfer students who had the highest first-term GPA. Hispanic or Latino and Asian students had an average first-term GPA that was 0.24 points lower than White students. The Other race/ethnicity category had the closest GPA compared to White students (*M*=2.70, *SD*=1.05). There was a 0.2 difference in first-term GPAs for traditional and non-traditional students. Students who did not earn an associate degree or AA, AFA, or AGE had similar first-term GPAs while students who earned an AAS had the highest average first-term GPA (*M*=2.81, *SD*=1.20). AS completers had the second highest first-term GPA (*M*=2.78, *SD*=0.93).

On average, 60.53 hours (*SD*=1.08, Min=12, *Max*=120) of transfer credit hours were applied to engineering students' undergraduate degrees at the RI. Differences in applying transfer hours to a baccalaureate degree were apparent when the data were disaggregated by associate degree type earned. In the sample, 74.5% of AAS degree completers had 60 or more transfer credit hours applied toward a baccalaureate engineering technology degree. In addition, 6.4% used fewer than 30 transfer credit hours toward a baccalaureate engineering technology degree. Only 41% of AAS degree completers could apply 60 or more transfer credit hours toward a baccalaureate engineering degree. More than a quarter of AAS degree completers (27.5%) could apply fewer than 30 hours of transfer credit toward an engineering baccalaureate degree.

Table 7

Means and Standard Deviations of First-Term GPA and Academics by Student-Influenced Variables (N=4,163)

Variable	First-Term GPA	Applied Transfer Hours	First-Term Attempted Hours	First-Term Earned Hours
Gender				
Female	2.69(1.12)	64.24(20.49)	11.71(3.99)	10.49(4.50)
Male	2.71(1.08)	60.05(20.95)	11.74 (3.92)	10.68(4.32)
Race/Ethnicity				
Black or African American	2.41(1.13)	58.03(23.18)	11.44(3.89)	10.04(4.45)
Hispanic or Latino	2.54(1.10)	58.98(20.05)	11.60(3.90)	10.28(4.32)
Other	2.70(1.05)	59.76(19.30)	11.91(3.98)	10.79(4.43)
Asian	2.54(1.04)	57.45(17.74)	12.35(3.49)	11.03(4.05)
White	2.78(1.07)	61.40(21.10)	11.72(3.96)	10.74(4.33)
Age				
23 or younger	2.61(0.99)	54.73(19.09)	13.20(2.72)	11.96(3.63)
24 and older	2.81(1.16)	66.42(21.10)	10.25(4.38)	9.34(4.60)
Pell Grant Eligible				
No Pell Grant awarded	2.75(1.18)	61.37(21.77)	10.63(4.52)	9.61(4.78)
Pell Grant awarded	2.68(1.00)	59.94(20.32)	12.51(3.24)	11.39(3.84)
Associate Degree Awarded				
No associate degree earned	2.62(1.04)	51.58(19.95)	12.54(3.53)	11.24(4.15)
AA, AFA, or AGE earned	2.65(1.06)	68.21(14.70)	12.42(3.10)	11.43(3.80)
AAS earned	2.81(1.20)	67.33(21.47)	9.87(4.42)	9.08(4.64)
AS earned	2.78(0.93)	70.02(12.82)	12.77(2.96)	11.69(3.62)
Type of Engineering Major				
Engineering	2.60(1.02)	58.35(19.25)	12.96(2.90)	11.62(3.79)
Engineering Technology	2.83(1.13)	62.96(22.44)	10.38(4.45)	9.59(4.66)

Eighty percent of AS degree completers had 60 or more transfer credit hours applied toward a baccalaureate engineering technology degree. The other 20% had at least 40 hours applied towards a baccalaureate engineering technology degree. Nearly 89% of AS degree completers had more than 60 hours to transfer credit applied towards a baccalaureate engineering degree. The other 20% were able to use at least 28 hours toward the baccalaureate. In comparison, 35% of transfer students who did not earn an associate degree were able to apply 60 or more transfer credit hours toward a baccalaureate engineering technology degree. Similarly, 34% of students who did not earn an associate degree were able to apply 60 or more transfer credit hours toward a baccalaureate engineering degree.

Overall, transfer students attempted an average of 11.74 credit hours (*SD*= 3.93) and earned an average of 10.66 credit hours (*SD*=4.34) during their first semester at the RI. Disaggregating the data by type of engineering degree uncovered differences in attempted hours. Of the engineering technology students, 56% attempted at least 12 hours, and 31% attempted six or fewer credit hours during their first semester. In comparison, 86% of engineering students attempted at least 12 hours during their first semester, and 2.7% attempted 6 hours or less. In addition, there were differences between engineering degree types when reviewing earned credit hours during the first semester. Forty-six percent of engineering technology students earned at least 12 credits, and 35% earned 6 hours or less during their first semester. Of the engineering students, 67% earned 12 or more credit hours, and 12% earned less than 6 hours during their first semester. The differences indicate that 10% of engineering technology students who attempted more than 12 hours earned less than 12 credits hours. Nearly 20% of engineering students who attempted more than 12 hours earned less than 12 credit hours during their first semester.

Table 8 reports the descriptive statistics of post-transfer academic predictor variables on the outcome variable for research questions 3 and 4, *Degree Completion* and includes all students in the sample. Table 9 provides the descriptive results of post-transfer academic predictor variables for the 2,471 engineering transfer students who completed a baccalaureate degree (i.e., persisters). The sample includes vertical transfer students who started as an engineering or engineering technology (ENGR/ET) major at the RI. In addition, a subset of the sample changed majors outside of the college/department of engineering and graduated with non-ENGR/ET bachelor's degrees. Overall, 53% of the students earned baccalaureate degrees, of those 49% earned an ENGR/ET baccalaureate degree, and 4% changed their major to a non-ENGR/ET degree and earned a baccalaureate degree at the RI.

A slightly higher percentage of men from the sample earned ENGR/ET baccalaureate degrees, 49.46% compared to 47.37% of women. While a higher rate of women changed their major outside of the college/department of engineering and completed non-engineering/engineering technology baccalaureate degrees, 4.84% compared to 3.93% of men. On average, women engineering/engineering persisters earned on average 0.11 points higher cumulative GPA at the RI than men persisters. Both men and women engineering/engineering technology persisters completed their coursework at the RI, on average, in less than seven semesters. These data show that while men and women students had approximately four semesters of transfer credit applied to their baccalaureate degree (see Table 7), they spent, on average, six semesters at the RI completing the remaining baccalaureate coursework.

Examining the engineering/engineering technology bachelor's degree earned by race/ethnicity suggests differences in persistence rates. Forty-two percent of Black or African American students earned a baccalaureate degree in ENGR/ET, and 5.34% earned non-ENGR/ET baccalaureate degrees, compared to 50.32% and 3.53% of White students, respectively. While 47.81% of Hispanic or Latino, 47.42% of Other, and 53.38% of Asian students earned a baccalaureate degree in engineering/engineering technology and 4.38%, 4.69%, and 6.33%; respectively earned non-engineering/engineering technology baccalaureate degrees. In addition, on average, Black or African American and Asian students earned 0.l8 and 0.17 points lower; respectively, compared to White students.

Table 8

Summary of Degree Completion and Means of Post-Transfer Academic Predictors (All Terms) (N=4,163)

Variable	ENGR/ ET Degree Compl. (%)	Non-ENGR/ET Degree Compl. (%)	Total Sems. at RI	Cum. GPA at RI	Total Earned Hours at RI	Cum. Hours Earned in Higher Ed
Gender						
Female	47.37	4.84	5.41(2.42)	2.95(0.85)	68.87(37.23)	134.38(39.83)
Male	49.46	3.93	5.57(2.56)	2.89(0.82)	68.57(36.81)	130.62(37.39)
Race/Ethnicity						
Black or A.A.	41.99	5.34	5.64(2.58)	2.66(0.82)	65.34(37.89)	128.29(40.43)
Hispanic or Latino	47.81	4.38	5.63(2.44)	2.82(0.80)	68.05(35.09)	129.47(37.24)
Other	47.42	4.69	5.59(2.40)	2.88(0.83)	71.16(36.48)	132.81(36.73)
Asian	53.38	6.33	5.52(2.34)	2.74(0.84)	74.22(39.37)	131.81(39.85)
White	50.32	3.53	5.53(2.43)	2.95(0.82)	68.30(36.67)	131.26(37.29)
Age						
23 or younger	56.24	4.81	5.59(2.29)	2.82(0.79)	75.61(36.59)	131.30(38.15)
24 and above	42.08	3.24	5.51(2.58)	2.98(0.85)	61.28(35.69)	130.78(37.21)
Pell Grant Eligible						
no Pell Grant awarded	44.43	3.26	5.41(2.65)	2.94(0.89)	61.58(36.86)	125.24(38.50)
Pell Grant awarded	52.58	4.58	5.65(2.28)	2.87(0.78)	73.37(36.08)	134.98(36.61)
Associate Degree Awarded						
no assoc. degree earned	50.88	5.03	5.71(2.46)	2.86(0.80)	77.10(38.87)	129.93(39.92)
AA, AFA, AGE earned	53.05	5.78	5.14(2.50)	2.86(0.85)	67.15(39.35)	136.53(41.02)
AAS earned	39.32	1.32	5.43(2.58)	2.93(0.87)	52.87(28.36)	126.42(34.66)
AS earned	61.26	5.67	5.55(2.01)	2.95(0.80)	74.44(34.02)	140.50(32.56)
Type of Engineering Major						
Engineering	54.45	5.61	5.63(2.32)	2.85(0.81)	77.74(38.40)	134.90(39.45)
Engineering Technology	43.40	2.28	5.46(2.57)	2.95(0.83)	58.13(31.93)	126.03(35.06)

Based on the descriptive statistics alone, there is a clear difference in the baccalaureate degree attainment rates between traditional and non-traditional age students. Transfer students of traditional age persisted at 56.42% in engineering/engineering technology and 4.81% in non-engineering/engineering technology degrees, compared to 42.08% and 3.24%, respectively, of non-traditional age students. Though, non-traditional age persisters earned, on average, 0.11 points higher cumulative GPA compared to traditional age persisters. The difference between total credit hours earned between the two subgroups is analogous with the differences in applied transfer credits hours described previously.

Table 9

Means and Standard Deviations of Post-Transfer Academic All-Terms Predictors for ENGR/ET Persisters by Student-Influenced Variables (N=2,471)

Variable	Total Semesters at RI	Cum. GPA at RI	Total Earned Hours at RI	Cum. Hours Earned in Higher Ed
Gender				
Female	6.32(2.07)	3.28(0.43)	91.82(25.73)	156.36(21.78)
Male	6.44(1.79)	3.17(0.49)	91.03(24.59)	151.75(19.80)
Race/Ethnicity				
Black or African American	6.61(1.79)	3.03(0.46)	91.92(24.25)	151.65(17.05)
Hispanic or Latino	6.50(1.98)	3.12(0.44)	91.53(20.47)	151.86(18.73)
Other	6.38(1.77)	3.17(0.48)	92.66(22.77)	153.10(17.96)
Asian	6.65(1.51)	3.04(0.45)	97.12(24.74)	155.69(21.80)
White	6.38(1.84)	3.21(0.49)	90.26(25.24)	151.96(20.65)
Age				
23 or younger	6.46(1.61)	3.13(0.47)	94.80(22.68)	151.16(18.67)
24 and above	6.38(2.07)	3.24(0.50)	86.11(26.43)	153.75(21.76)
Pell Grant Eligible				
No Pell Grant awarded	6.38(1.99)	3.23(0.48)	86.67(24.78)	149.47(19.14)
Pell Grant awarded	6.45(1.72)	3.15(0.48)	93.75(24.30)	153.91(20.44)
Associate Degree Awarded				
No associate degree earned	6.66(1.81)	3.15(0.46)	100.74(23.35)	151.81(20.51)
AA, AFA, or AGE earned	6.24(1.81)	3.17(0.47)	89.67(26.08)	160.21(24.95)
AAS earned	6.16(2.01)	3.22(0.53)	72.95(16.78)	147.68(15.11)
AS earned	6.27(1.39)	3.21(0.48)	91.34(22.49)	155.86(20.82)
Type of Engineering Major				
Engineering	6.55(1.65)	3.17(0.46)	99.86(22.97)	156.44(20.77)
Engineering Technology	6.25(2.02)	3.19(0.51)	78.89(21.71)	146.40(17.47)

According to the Pell Grant eligibility variable, there is a clear difference in persistence rate by examining descriptive statistics alone. The percentage of students who received a Pell Grant at some point during their time at the RI and earned engineering/engineering technology baccalaureate degrees was 52.58%, while 4.58% changed their major and earned non-engineering/engineering technology degrees. In comparison, 44.43% of students who were not awarded a Pell Grant earned baccalaureate ENGR/ET degrees, and 3.26% earned baccalaureate non-ENGR/ET degrees. On average, ENGR/ET persisters who were not awarded a Pell Grant earned 0.08 points higher cumulative GPA than Pell Grant eligible persisters. The difference between total credit hours earned between the two subgroups is parallel with the differences in applied transfer credits hours described previously.

Disaggregated by associate degree type, the findings suggest apparent differences in persistence rates by degree type. Overall, only 39.32% of AAS completers earned an engineering or engineering technology baccalaureate degree, and 1.32% earned a non-engineering baccalaureate degree. Specifically, 38.71% of engineering technology majors and 45.00% of engineering majors persisted to degree attainment. In contrast, close to 67% of AS completers earned an engineering technology baccalaureate degree, 61.26% achieved an engineering baccalaureate degree, and 5.67% changed their major and earned non-engineering/engineering technology baccalaureate degrees. Students who earned an AA, AFA, or AGE earned more engineering/engineering technology degrees and non-engineering degrees than AAS completers at 53.05% and 5.78%, respectively. Students without an associate degree earned engineering degrees at 50.88%.

Additionally, there were differences between associate degree types in average total credit hours earned at the RI. For example, AAS completers who persisted to ENGR/ET baccalaureate degrees earned the fewest credit hours at the RI even though they transferred fewer credit hours than AA, AFA, AGE, and AS persisters (see Table 7). On average, AAS completers had roughly 148 cumulative hours in their career (i.e., applied transfer hours and credit hours earned at the RI) compared to AA, AFA, AGE, and AS completers who had 160 and 156 cumulative hours, respectively.

The cumulative hours earned in career ranged, on average, from 146 to 160 hours for all subpopulations in this study. On average, engineering persisters earned 100 hours over 6.55 semesters at the RI and had 156 cumulative hours in their career. Engineering technology persisters earned, on average, 79 hours over 6.25 semesters and had a total of 146 cumulative hours in their career. While engineering and engineering technology persisters took between six or seven semesters to complete their baccalaureate degrees, engineering majors earned close to 20 hours more than engineering technology students at the RIs.

Of the sample, 394 students left the RI after one semester, and another 357 left after the second semester. Disaggregating by engineering degree type, more engineering technology majors left the RI after the first semester than engineering majors, 10% compared to 7.5%. Though slightly more engineering majors left after the second semester, 9% versus 8%, compared to engineering technology majors.

Institution Characteristics

Next, the college/department of engineering characteristic variables are discussed as they relate to *First-Term GPA* and *Degree Completion* outcomes and the student characteristics. The *Advising* variable was removed from the data analysis since only one school offered transfer-specialized advisors dedicated to transfer students. Table 10 provides the vertical transfer student enrollment by the Carnegie Classification of Institutions of Higher Education, transfer orientation, and selected student characteristic variables. Several of the RIs included in this study had changes in their basic and selectivity classifications from 2009 to 2016 captured in these data. These data indicate that the RIs in this study were predominately selective in undergraduate admissions and offered transfer-focused orientation. A higher percentage of female students from the sample attended RIs classified as doctoral universities with very high research activity or institutions that were inclusive in their undergraduate admissions. A higher percentage of the underrepresented minority students in the sample attended RIs classified as doctoral universities with high research activity and were classified as inclusive in their undergraduate admissions.

Table 10

Enrollment by Institution-Influenced Variables

Variable	N	Frequency (%)	% Female Students	% URM Students	% Pell Grant
Basic Classification					
Master's Universities	256	6.15	5.86	7.03	51.56
Doctoral University	1414	33.97	9.83	14.99	55.09
Doctoral Uni.- High	1658	39.83	10.92	23.94	61.04
Doctoral Uni.- Very High	835	20.06	16.77	10.18	62.63
Selectivity Classification					
Inclusive	252	6.15	15.08	46.43	68.25
Selective	2555	61.37	9.47	15.62	55.66
More Selective	1356	32.57	14.31	14.45	62.83
Transfer-Focused Orientation					
Not Offered	1607	38.60	12.07	20.97	52.27
Offered	2556	61.40	10.99	14.67	62.83
Transfer-Specialized Advising					
No Dedicated Transfer Advising	3328	79.94	10.07	18.84	57.78
Dedicated Transfer Advising	835	20.06	16.77	10.18	62.63

Moreover, the descriptive statistics from the *Transfer-Specialized Advising* were precisely equal to the institutions classified as doctoral universities with very high research. Therefore, the *Advising* variable was not included in the regression analyses due to the lack of variability in advising between the five institutions. Furthermore, the *Advising* variable was removed from the remaining descriptive statistics since the results were the same as doctoral universities with very high research.

Table 11 summarizes the institution-influenced variables by RIs included in this study. These data incorporate the enrollment and percentage of female and underrepresented minority (URM) faculty members in the college/department of engineering at each institution.

Additionally, average class size data include only undergraduate engineering or engineering lectures, labs, seminars offered by the college/department of engineering at each RI. While there were some changes in faculty makeup and class sizes between 2009 and 2016 the changes were minimal, so these data are presented by each institution. Overall, students in the sample were exposed to a college/department of engineering faculty with nearly 20% female faculty and almost 7% URM faculty. The sample of students had close to 11% female and nearly 17% URM transfer students. There were clear differences in the percentage of female and URM faculty. On average, ECU had the highest female faculty representation (30%), while WCU had the lowest at nearly 4%. NC A&T had the highest representation of URM faculty members (45.27%), while ECU had the lowest representation at close to 1%. Additionally, there were clear differences in the average class size. NC State had the smallest average class size at 17.31, while Charlotte had the largest at 31.70.

Table 11

Enrollment and Continuous Institution-Influenced Predicators at RIs

RI	N	% Female Faculty	% URM Faculty	Average Class Size
ECU	1,355	30.29	1.10	23.19
NC A&T	252	12.55	45.27	21.00
NC State	835	16.02	5.59	17.31
Charlotte	1,465	16.10	6.47	31.70
WCU	256	4.53	3.34	24.98

Table 12 reports the descriptive statistics of institution characteristics and predictor variables on the outcome variable for research questions 1 and 2, *First-Term GPA*. Based on descriptive statistics alone, there were observed differences in the mean *First-Term GPA* based on the RI's classifications. On average, students' first-term GPAs were 0.52 points higher at RIs classified as master's universities compared to institutions classified as doctoral universities with very high research. On average, students' first term GPA decreased as the number of doctoral degrees offered, and research activity increased at the RIs. On average, students earned up to 0.21 points higher first-term GPA at RIs classified as selective in their undergraduate admissions compared to inclusive and more selective admissions. Students who attended RIs without transfer-focused orientations earned, on average, 0.41 points higher first-term GPA compared to institutions that did not offer transfer-focused orientations.

Table 12

First-Term GPA and Select Academic Predictors Means and Standard Deviations by RI Characteristics (N=4,163)

Variable	First-Term GPA	Applied Transfer Hours	First-Term Attempted Hours	First-Term Earned Hours
Basic Classification				
Master's University	3.07(0.99)	54.93(22.38)	11.02(4.78)	10.37(4.93)
Doctoral University	2.79(1.10)	63.54(21.55)	11.03(4.20)	10.40(4.38)
Doctoral Uni.- High Research	2.66(1.06)	55.74(20.23)	11.72(3.87)	10.44(4.43)
Doctoral Uni.- Very High Research	2.55(0.94)	66.75(18.09)	13.19(2.71)	11.71(3.60)
Selectivity Classification				
Inclusive	2.62(1.17)	46.47(19.74)	12.71(3.54)	11.78(4.34)
Selective	2.79(1.10)	61.53(21.62)	11.04(4.22)	10.33(4.47)
More Selective	2.58(1.00)	61.37(18.83)	12.89(3.00)	11.13(3.96)
Transfer-Focused Orientation				
Not Offered	2.96(1.06)	64.98(23.20)	10.44(3.38)	9.80(4.57)
Offered	2.55(1.07)	57.78(18.87)	12.56(3.38)	11.23(4.07)

On average, students who attended RIs classified as doctoral universities with very high research had close to 12 hours more of transfer credit hours applied to their baccalaureate degree upon entry compared to master's universities which had the fewest transfer credits applied. RIs that had selective or more selective undergraduate admissions policies applied similar transfer credit hours to a baccalaureate degree compared to institutions with inclusive admissions policies that applied 15 fewer transfer credit hours. On average, institutions that did not offer transfer-focused orientations applied over seven hours of transfer credit compared to institutions that offered transfer-focused orientations.

There was a 1.5-hour difference between attempted and earned credit hours during the first term who attended doctoral universities with very high research activity compared to a difference of 0.6-hour difference for students who attended institutions classified as master's universities and doctoral universities. There were similar observed differences between the selectivity classifications. On average, there was a 1.8-hour difference between attempted and earned credit hours during the first term for students who attended institutions with more selective admission policies compared to a 0.7-credit hour difference for selective admissions.

Table 13 summarizes select institutional characteristics by the outcome variable, *Degree Completion*, and select predictor variables for all students in the sample. Table 14 summarizes notable institutional characteristics and post-transfer academic variables of ENGR/ET persisters. For both tables, transfer-specialized advising is omitted since the results are the same as doctoral universities with very high research.

Disaggregated by institutional classifications, differences in the *Degree Completion* variable were observed. Sixty-one percent of students who attended a master's university earned a baccalaureate degree in engineering/engineering technology, and 1.56% earned a non-engineering or engineering technology baccalaureate degree, compared to 45.29% and 4.16% of doctoral universities with high research. Close to 48% of students who attended doctoral universities and 55.81% of students who attended doctoral universities with very high research activity persisted to baccalaureate ENGR/ET degree attainment, and 3.75% and 5.03%; respectively earned non-engineering or engineering technology baccalaureate degrees. On average, ENGR/ET persisters who attended a master's university earned the highest cumulative

GPA compared to persisters who attended doctoral universities, doctoral universities with high and very high research. Similarly, there was an increase in total hours earned and cumulative hours earned in higher education as doctoral degrees and research activity increased.

Table 13

Summary Degree Completion and Select Predictor Variables by Institutional Characteristics (N=4,163)

Variable	ENGR/ET Degree Compl. (%)	Non-ENGR/ET Degree Compl. (%)	Cum. GPA at RI	Total Earned Hours at RI	Cum. Hours Earned in Higher Ed.
Basic Classification					
Master's University	61.33	1.56	3.03(0.97)	61.39(38.30)	126.30(38.70)
Doctoral University	47.74	3.75	2.96(0.77)	63.18(32.13)	131.62(35.27)
Doct. Uni.- High Res.	45.29	4.16	2.85(0.83)	66.92(36.11)	126.33(37.84)
Doct. Uni.- Very High Res.	55.81	5.03	2.85(0.86)	82.50(41.08)	140.40(39.03)
Selectivity Classification					
Inclusive	52.38	2.38	3.05(0.73)	71.65(37.55)	122.40(42.05)
Selective	46.65	3.48	2.93(0.81)	63.09(33.50)	129.96(35.72)
More Selective	53.47	5.38	2.81(0.87)	77.91(40.36)	134.44(39.94)
Transfer-Focused Orient.					
Not Offered	44.56	2.12	3.03(0.75)	60.78(30.20)	132.00(34.18)
Offered	52.15	5.24	2.82(0.76)	73.42(39.65)	130.45(39.69)

Close to 54% of students who attended institutions with more selective undergraduate admission policies earned a baccalaureate degree in engineering or engineering technology, and 5.38% earned a non-engineering/engineering technology baccalaureate degree, compared to 46.65% and 3.48% institutions with selective admissions. In comparison, 52.38% of students who attended institutions with inclusive admission policies graduated with engineering or engineering technology degrees, and 2.38% earned non-engineering/engineering technology baccalaureate degrees. On average, ENGR/ET persisters who attended a university with inclusive admissions policies earned the highest cumulative GPA compared to persisters who attended universities with selective and more selective admissions policies. The difference between total credit hours earned at the RI between the selectivity subgroups is parallel with the differences in applied transfer credits hours described previously. There was an increase in cumulative hours earned in higher education as undergraduate admission selectivity increased.

Table 14

Summary of Select Institution-Influenced Variables by ENGR/ET Persisters' Academics (N=2,471)

Variable	Total Semesters at RI	Cum. GPA at RI	Total Earned Hours at RI	Cum. Hours Earned in Higher Ed.
Basic Classification				
Master's University	6.44(1.71)	3.32(0.53)	80.09(30.02)	146.47(22.85)
Doctoral University	6.59(2.19)	3.16(0.49)	83.32(19.66)	150.59(15.72)
Doctoral Uni.- High Research	6.47(1.63)	3.17(0.47)	91.13(19.21)	150.75(15.02)
Doctoral Uni.- Very High Research	6.11(1.52)	3.17(0.47)	106.08(29.64)	159.03(28.51)
Selectivity Classification				
Inclusive	6.34(1.89)	3.31(0.44)	91.73(18.45)	147.35(15.43)
Selective	6.54(1.98)	3.17(0.50)	84.07(21.57)	150.41(16.90)
More Selective	6.25(1.51)	3.16(0.47)	102.58(26.22)	156.18(24.52)
Transfer-Focused Orientation				
Not Offered	6.35(2.06)	3.20(0.50)	79.61(18.74)	150.27(16.74)
Offered	6.46(1.68)	3.17(0.48)	97.30(25.32)	153.32(21.59)

Among persisters, nearly 52% attended an institution with transfer-focused orientations while 45% attended an institution without transfer-focused orientation. A higher percentage of students exposed to a transfer-focused orientation graduated with non-engineering or engineering technology degrees than students who attended institutions that did not provide transfer-focused orientation, 5.24% versus 2.12%, respectively. The total cumulative GPA was similar between the two orientation subgroups. The difference between total credit hours earned between the two orientation subgroups is parallel with the differences in applied transfer credits hours described previously.

Multiple Linear Regression Findings

Model 1: Research Question 1

A multiple linear regression model was conducted to determine if first-term GPA at the RI could be predicted from a series of blocked variables organized by Smith and Van Aken's (2020) Engineering Transfer Student Persistence conceptual framework. The blocks were entered into the model in hierarchical steps. The first step included student characteristics and pre-transfer academic predictors, the second step included institution-influenced predictors, and the last step included post-transfer academics. The unstandardized regression coefficients (*B*), robust standard errors (*SE*), and level of significance (*p*-value) are presented in Table 15. The results from each block explain a greater amount of the variation in engineering transfer students' first-term GPAs as more variables were added. The full model suggests that a significant proportion of the total variation in first-term GPA was predicted by student background, pre-transfer academics, institution, and post-transfer academic factors, ($R^2 = .325$, $F(16, 4133) = 124.29$, $p < .001$). The variables that had a statistically significant relationship to academic success will be discussed first, followed by variables that had no statistically significant impact on first-term GPA.

For student-influenced sociodemographic variables, race/ethnicity and age emerged as significant predictors of first-term GPA. In the race/ethnicity component, being Black or African American ($B = -0.27$, $SE = 0.05$, $p < .001$) and Hispanic or Latino ($B = -0.13$, $SE = 0.06$, $p < .02$) were negative predictors of first-term GPA. On average, Black or African American students scored 0.27 points lower on first-term GPA than White transfer students. For Hispanic students, on average, scored 0.13 points lower on first-term GPA than White transfer students. Transfer students being of non-traditional age ($B = 0.13$, $SE = 0.03$, $p < .001$) were a positive predictor of first-term GPA. Transfer students being of non-traditional age scored, on average, 0.13 points higher on first-term GPA than traditional age transfer students. For the pre-transfer academic variables, the number of applied transfer hours contributed significantly to the prediction of first-term GPA. Applied transfer hours (*B* = 0.003, *SE* = 0.00, $p < .001$) was a positive predictor of first-term GPA. There was a predicted increase of .003 points on first-term GPA for every one-hour increase in applied transfer hours.

Table 15

RQ1 Model 1 Coefficients, Robust Standard Errors (N=4,150)

Variable	Block 1	Block 2	Block 3
	B (SE)	*B (SE)*	*B (SE)*
Student-Influenced Predictors			
Female	-0.02(0.05)	-0.02(0.06)	0.01(0.05)
Black or African American	-0.36(0.06)***	-0.43(0.06)***	-0.27(0.05)***
Hispanic or Latino	-0.21(0.07)***	-0.23(0.08)**	-0.13(0.06)*
Other	-0.08(0.06)	-0.04(0.07)	-0.06(0.05)
Asian	-0.20(0.07)**	-0.13(0.09)*	-0.12(0.06)
Age (24 and above)	0.13(0.04)***	0.12(0.04)**	0.13(0.03)***
Pell (eligible)	-0.01(0.04)	0.03(0.04)	-0.04(0.03)
Pre-Transfer Academics:			
Applied Transfer Hours	0.01(0.00)***	0.01(0.00)***	0.00(0.00)***
AA, AFA, AGE	-0.06(0.08)	-0.18(0.08)	-0.11(0.06)
AAS	0.07(0.05)	-0.13(0.05)	-0.03(0.04)
AS	0.05(0.07)	0.16(0.07)	0.03(0.04)
Institution-Influenced Predictors			
Female Faculty		0.00(0.00)***	0.01(0.00)***
URM Faculty		-0.01(0.00)	0.00(0.00)
Average Class Size		-0.05(0.01)***	-0.00(0.00)
Predictors Influenced by Both Student and Institution			
Post-Transfer Academics First Term:			
First-Term Attempted Hours			-0.22(0.01)***
First-Term Earned Hours			0.24(0.01)***
Model Summary			
F	13.16***	14.34***	124.29***
R^2	.034	.048	.325
ΔR^2		.014	.277

Note. b=regression coefficient*; SE*= heteroscedastic consistent (HC4) standard error

The reference variable for Race/Ethnicity was White, for Associate Degree was no associate degree

**p*<.05, ***p*<.01, ****p*<.001

For institution-influenced variables, female faculty representation in the college/department of engineering (*B* = 0.01, *SE* = 0.00, $p < .001$) emerged as a significant positive predictor of first-term GPA. There was a predicted increase of .01 points on first-term GPA for each one percent increase in female faculty. All first-term post-transfer academic variables contributed significantly to the prediction of first-term GPA. Attempted hours first-term (*B* = -0.22, *SE* = 0.01, $p < .001$) was a negative indicator of first-term GPA. For each hour increase in attempted hours first-term, there was a predicted decrease of 0.22 points on first-term GPA. Contrastingly, earned hours first-term (*B* = 0.24, *SE* = 0.01, $p < .001$) was a positive indicator of first-term GPA. For each hour increase in earned hours first-term, there was a predicted increase of 0.24 points on first-term GPA.

Several variables were not statistically significant predictors of first-term GPA at the RI. Gender, Other and Asian races/ethnicities, Pell Grant eligibility, associate degree types, URM faculty, and average class size variables were not statistically significant in the final model.

Model 2: Research Question 2

To determine if institutional-influenced factors moderate the relationship between applied transfer hours and first-term GPA, interaction terms for the percentage of female faculty and URM faculty, average class size, and applied transfer hours were added to the regression model (Block 4). There was a modest increase (0.02) in the variation in engineering transfer students' first-term GPAs with the inclusion of the interaction terms. However, the full model suggests that a significant proportion of the total variation in first-term GPA was predicted by student, institution, both student and institution, and the interaction variables ($R^2 = .327$, F (19, 4130) = 105.77, $p < .001$). The unstandardized regression coefficients (*B)*, robust standard errors (*SE)*, and level of significance (*p*-value) are presented in Table 16.

Table 16

RQ2 Model 2 Coefficients and Robust Standard Errors (N=4,150)

Variable	Block 4
	B (SE)
Student-Influenced Predictors	
Female	0.01(0.04)
Black or African American	-0.27(0.05)***
Hispanic or Latino	-0.13(0.06)*
Other	-0.05(0.05)
Asian	-0.12(0.06)
Age (24 and above)	0.13(0.03)***
Pell (eligible)	-0.04(0.03)
Pre-Transfer Academics:	
Applied Transfer Hours	0.00(0.00)**
AA, AFA, AGE	-0.09(0.06)
AAS	-0.02(0.04)
AS	0.05(0.04)
Institution-Influenced Predictors	
Female Faculty	0.01(0.00)***
URM Faculty	0.00(0.00)
Average Class Size	-0.00(0.00)**
Predictors Influenced by Both Student and Institution	
Post-Transfer Academics:	
First-Term Attempted Hours	-0.22(0.01)***
First-Term Earned Hours	0.24(0.01)***
Interaction	
Female Fac. x Appl. Trans. Hrs.	0.00(0.00)***
URM Fac. x Appl. Trans. Hrs.	0.00(0.00)*
A. Class x Appl. Trans. Hrs.	-0.00(0.00)
Model Summary	
F	105.77***
R^2	.327

Note. b=regression coefficient*; SE*= heteroscedastic consistent standard error

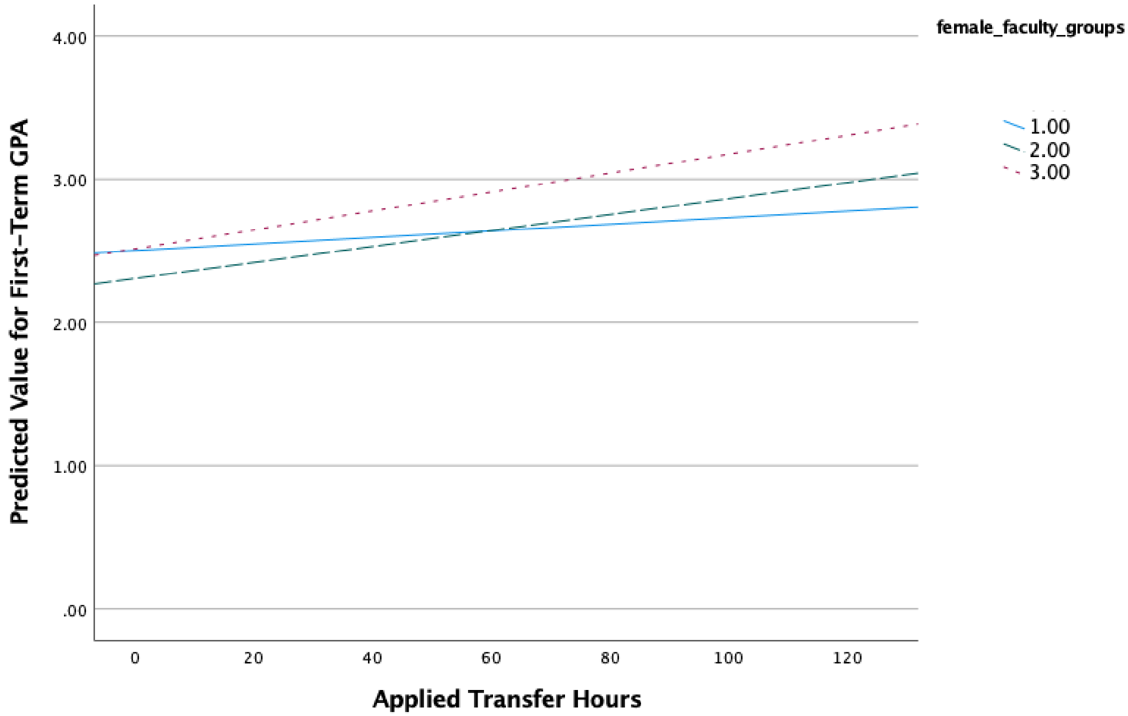
The reference variable for Race/Ethnicity was White, for Associate Degree was no associate degree

*p<.05, **p<.01, ***p<.001

The interaction between the proportion of female faculty and applied transfer hours (*B*=0.0003) was statistically significant at $p < .001$. As the percentage of female faculty increased, the influence of the applied transfer hours on First Term GPA increased. The significant interaction was probed further to understand the nature of the interaction (Robinson et al., 2013). The simple effect coefficients or simple slopes were computed by dividing the centered female faculty predictor into three groups. Group 1 was values less than minus one standard deviation from the mean (-0.82), Group 2 was set as the range of +/- one standard deviation (-0.82 to 0.82), and Group 3 was set as values greater than one standard deviation (0.82) (ECU) from the mean. A plot of the predicted values for first-term GPA was plotted against the applied transfer hours variable with set markers by the three groups of female faculty-see Figure 3. The slopes were positive for all groups, indicating that as the applied transfer hours increased, the predicted first-term GPA increased. The slopes for Groups 2 and 3 were similar, indicating that the amount of applied transfer hours was similarly influential in predicting a student's first-term GPA. However, the slope for Group 1 was less than the slopes for Groups 2 and 3, which indicated applied transfer hours were less influential in predicting the probability of first-term GPA at institutions with fewer female faculty.

Figure 3

Simple Slopes of the Interaction between Proportion of Female Faculty and Transfer Hours

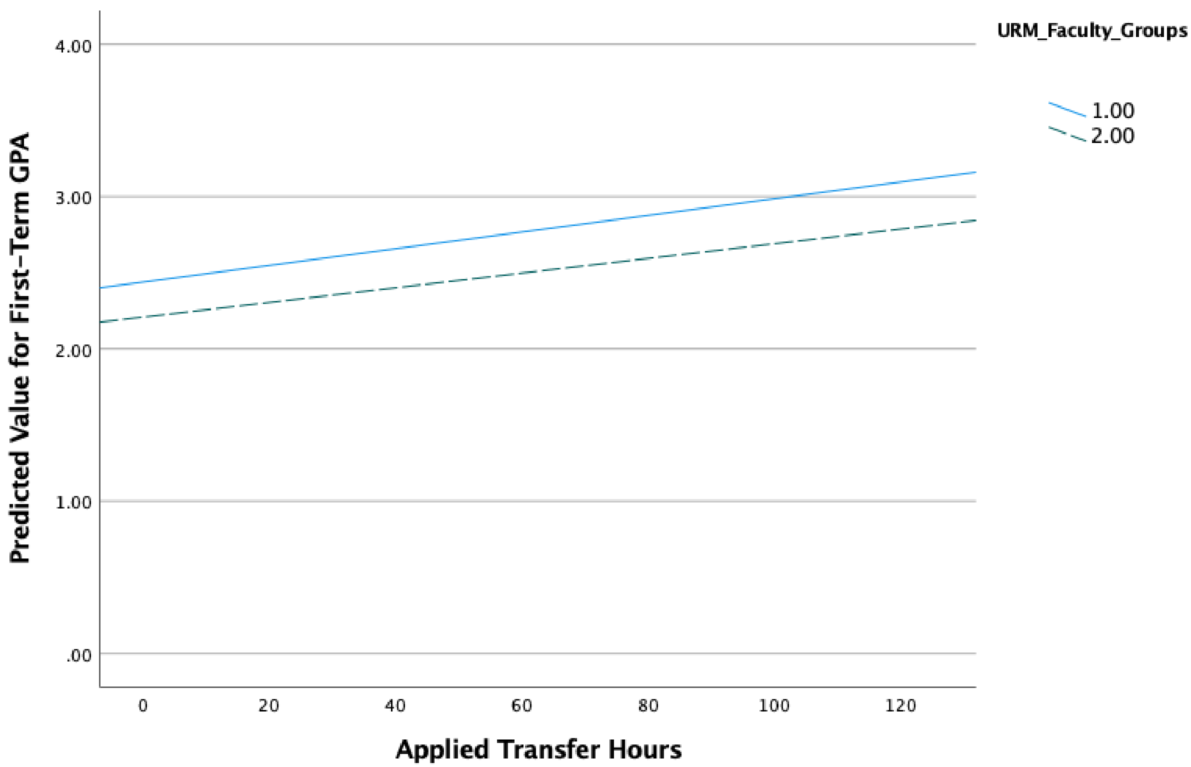


The interaction between proportion of URM faculty and applied transfer hours (*B*=0.0002) was statistically significant at *p* = .029. As applied transfer hours increased, the influence of the URM faculty on First Term GPA increased. The significant interaction was probed further to understand the nature of the interaction (Robinson et al., 2013). First, the simple effect coefficients or simple slopes were computed by dividing the centered URM faculty predictor into two groups. The percentages of URM faculty were either less than 10% or more than 40% at the RIs. Therefore, Group 1 was values less than the mean, and Group 2 was values greater than the mean. Next, a plot of the predicted values for First-Term GPA was plotted against the applied transfer hours variable with set markers by the two groups of URM faculty- see Figure 4. Based on the plot, an interaction effect is not evident. However, the slopes were positive and similar for Group 1 (ECU, NC State, Charlotte, and WCU) and Group 2 (NC A&T),

indicating that as the applied transfer hours increased, the predicted First Term GPA increased. The similar slopes between the groups indicate a similar influence of URM faculty was in predicting a student's first-term GPA. It was noted that there was a difference in the predicted first-term GPAs between the two groups. Students who attended college/Departments with lower percentages of URM faculty had a slightly higher predicted first-term GPA than college/Departments with higher percentages of URM faculty.

Figure 4

Simple Slopes of the Interaction between Proportion of URM Faculty and Transfer Hours



Logistic Regression Findings

Model 3: Research Question 3

A logistic regression was performed to ascertain the effects of a series of blocked variables on persistence in engineering to address research question 3. The blocks were entered into the model in the same hierarchical steps used for the multiple linear regression models. Each block was statistically significant, with Block 1: χ^2 = 145.83, p < .001, Block 2: χ^2 = 19.62, p < .001, and Block 3: χ^2 = 2491.33, p < .001. The model explained 66.6% (Nagelkerke R^2) of the variance in persistence and correctly classified 87.1% of the cases. The sensitivity was 94.5%, specificity was 74.8%, positive predictive value was 86.1%, and negative predictive value was 89.1%. The estimated coefficients, standard errors, and odds ratios (*OR*) are presented in Table 17.

Table 17

RQ3 Model 3 Coefficients, Standard Errors, and Odds Ratios (N=3,963)

Variable	Block 1		Block 2		Block 3	
	b (SE)	Odds Ratio	*b (SE)*	Odds Ratio	*b (SE)*	Odds Ratio
Student-Influenced Predictors						
Female	-0.07(0.10)	0.93	-0.10(0.10)	0.90	-0.19(0.16)	0.83
Black or African American	-0.43(0.11)	1.54***	-0.40(0.11)	0.67***	-0.12(0.18)	0.89
Hispanic or Latino	-0.23(0.13)	1.26	-0.17(0.13)	0.84	0.00(0.21)	1.00
Other	-0.06(0.11)	1.06	-0.05(0.11)	0.95	-0.22(0.17)	0.81
Asian	-0.05(0.16)	0.95	-0.01(0.15)	0.99	0.16(0.25)	1.17
Age (24 and above)	-0.57(0.07)	0.56***	-0.56(0.07)	0.57***	-0.34(0.12)	0.71**
Pell (eligible)	0.44(0.07)	1.55***	0.44(0.07)	1.55***	-0.00(0.11)	1.00
Pre-Transfer Academics:						
Applied Transfer Hours	0.01(0.00)	1.01***	0.01(0.00)	1.01***	0.02(0.00)	1.02***
AA, AFA, AGE	-0.14(0.13)	0.87	-0.13(0.13)	0.88	0.70(0.23)	2.02**
AAS	-0.29(0.08)	0.75***	-0.20(0.08)	0.82*	0.89(0.13)	2.44***
AS	0.32(0.11)	1.38**	0.32(0.11)	1.37**	0.67(0.16)	1.95***
Institution-Influenced Predictors						
Female Faculty			-0.01(0.00)	0.99**	-0.03(0.01)	0.97***
URM Faculty			-0.01(0.00)	1.00	-0.01(0.01)	0.99***
Average Class Size			-0.03(0.0)	0.97***	-0.03(0.01)	0.98**
Predictors Influenced by Both Student and Institution						
Post-Transfer Academics First Term:						
First-Term GPA					0.08(0.07)	1.08
First-Term Attempted Hours					0.03(0.02)	1.03
Post-Transfer Academics All Terms:						
Total Semesters					0.05(0.03)	1.05
Cumulative GPA					1.31(0.12)	3.69***
Total Earned Hours					0.07(0.00)	1.07***
Model Fit						
-2 x log likelihood	5103.68		5084.07		2591.74	
% Correct Predicted	63.5		64.3		87.1	

Note. b=regression coefficient*; SE*= standard error; the reference variable for Race/Ethnicity was White, and Associate Degree was no associate degree*;* *p<.05, **p<.01, ***p<.001.

For student-influenced variables, the relative likelihood of engineering or engineering technology degree attainment is significantly associated with age, the number of applied transfer hours, and certain associate degrees. There was a statistically significant and negative association between age and the probability of persistence or baccalaureate degree attainment (OR = 0.71, p < .001, 95% CI [0.57, 0.90]). This result indicates that the odds of non-traditional age transfer students to persist were 1.41 times less likely than the odds of traditional age students persisting. Applied transfer hours was a positive and statistically significant predictor (OR = 1.02, p < .001, 95% CI [1.01, 1.02]), which indicates that the odds of a student earning a baccalaureate degree increased by a factor of 1.17 with every 10-hour increase in applied transfer hours.

Additionally, the *AA, AFA, AGE* predictor was a positive and statistically significant predictor (OR = 2.02, p = .002, 95% CI [1.29, 3.17]), which indicates that students who had an AA, AFA, or AGE degree were 2.02 times more likely to earn a baccalaureate engineering or engineering technology degree compared to odds of students without an associate degree persisting. The *AAS* variable was a positive and statistically significant predictor (OR =2.44, p < .001, 95% CI [1.89, 3.15]), which indicates that students who had an AAS degree were 2.44 times more likely to earn a baccalaureate engineering or engineering technology degree compared to the odds of students who did not complete an associate degree persisting. The *AS* variable was a positive and statistically significant predictor (OR = 1.95, p < .001, 95% CI 1.41, 2.68]), which indicates that students who had an AS degree were 1.95 times more likely to earn a baccalaureate engineering or engineering technology degree compared to the odds of students without an associate degree persisting.

Regarding the effect of institution-influenced predictors, the percentage of female and URM faculty, average class size, and academic advising were significantly associated with persistence or baccalaureate engineering or engineering degree attainment. However, the odds ratios for each institution-influenced predictor were close to zero indicating negligible differences in the odds. The percentage of female faculty in the college/department of engineering was a negative and statistically significant predictor (*OR* = 0.97, $p < .001$, 95% CI [0.96, 0.99]). This result indicates that students were 1.03 times less likely to persist with each 1 percent increase in female faculty. The percentage of URM faculty in the college/department of engineering was a negative and statistically significant predictor (*OR* = 0.99, $p = .037$, 95% CI [0.98, 1.00]). This result indicates that students were 1.01 times less likely to persist with each 1 percent increase in URM faculty. The average class size of courses taught in the college/department of engineering was a negative and statistically significant predictor (*OR* = 0.98, $p < .001$, 95% CI [0.96, 0.99]). This result indicates that students were 1.03 times less likely to persist with each student increase in class size.

Of the post-transfer academic predictors, cumulative GPA and total hours earned at the RI were significantly associated with persistence or baccalaureate engineering or engineering degree attainment. Cumulative GPA was a positive and statistically significant predictor (*OR* = 3.69, $p < .001$, 95%, CI [2.95, 4.62]), which indicates that the odds of a student earning a baccalaureate degree increased by a factor of 3.69 with every one unit increase on the predictor cumulative GPA. In addition, total earned hours at the RI were found to be a positive and statistically significant predictor (*OR* = 1.07, $p < .001$, 95% CI [1.06, 1.08]), which indicates that the odds of a student earning a baccalaureate degree increased by a factor of 1.07 with every one hour increase in the predictor total earned hours at the RI.

Several predictors were not statistically significant predictors of persistence to engineering or engineering baccalaureate degree. While race/ethnicity and Pell Grant eligibility had a statistically significant impact on baccalaureate attainment in steps 1 or 2, these variables were not found to be statistically significant with the inclusion of post-transfer academic predictors. Gender, first-term GPA, and total semesters at the RI were not statistically significant predictors of persistence.

Model 4: Research Question 4

A logistic regression was performed to ascertain if any institution-influenced factors moderated the relationship between cumulative GPA and persistence or engineering/engineering technology degree completion to address research question 4. The blocks were entered into the model in hierarchical steps with the same steps as Model 3 with the addition of step 4, which included the interaction of cumulative GPA and institutional influenced predictors. Each block was statistically significant, with Block 1: χ^2 = 145.83, $p < .001$, Block 2: χ^2 = 19.61, $p < .001$, Block 3: χ^2 = 2492.33, $p < .001$, and Block 4: χ^2 = 35.65, $p = .001$. The model explained 67.2% (Nagelkerke R^2) of the variance in persistence and correctly classified 87.4% of the cases. There was a modest improvement from Model 3, with a 0.6% increase in Nagelkerke R^2 and a 0.3% increase in correctly classified cases. The sensitivity was 94.9%, specificity was 74.8%, positive predictive value was 86.1%, and negative predictive value was 89.9%. The estimated coefficients, standard errors, and odds ratios of the model are presented in Table 18.

Table 18

RQ4 Model 4 Coefficients, Standard Errors, and Odds Ratios (N=3,963)

Variable	Block 4	
	b (SE.)	Odds Ratio
Student-Influenced Predictors		
Female	-0.19(0.16)	0.82
Black or African American	-0.21(0.18)	0.81
Hispanic or Latino	-0.02(0.21)	0.98
Other	-0.19(0.17)	0.83
Asian	0.13(0.25)	1.14
Age (above 24)	-0.33(0.12)	0.72**
Pell (eligible)	-0.01(0.11)	0.99
Pre-Transfer Academics:		
Applied Transfer Hours	0.02(0.00)	1.02***
AA, AFA, AGE	0.65(0.23)	1.92**
AAS	0.87(0.13)	2.38***
AS	0.65(0.17)	1.92***
Institution-Influenced Predictors		
Female Faculty	-0.01(0.01)	0.97
URM Faculty	-0.01(0.01)	0.99
Average Class Size	-0.02(0.01)	0.97*
Predictors Influenced by Both Student and Institution		
Post-Transfer Academics: First Term		
First-Term GPA	0.06(0.07)	1.06
First-Term Attempted Hours	0.03(0.02)	1.03
Post-Transfer Academics: All Terms:		
Total Semesters	0.03(0.03)	1.03
Cumulative GPA	1.32(0.14)	3.76***
Total Earned Hours	0.07(.00)	1.07***
Interactions		
Female Faculty x Cumulative GPA	-0.06(0.01)	0.94***
URM Faculty x Cumulative GPA	-0.02(0.01)	0.98*
Class Size x Cumulative GPA	-0.04(0.02)	0.96*
Model Fit		
-2 x log-likelihood	2501.93	
% Correct Predicted	87.9	

Note. b=regression coefficient*; SE*= standard error

The reference variable for Race/Ethnicity was White, for Associate Degree was no associate degree

*p<.05, **p<.01, ***p<.001

The interaction between female faculty and cumulative GPA (OR = 0.94, p < .001, 95% CI [.0.98, 1.00]) was found to have a significant effect on the probability of persistence of engineering transfer students. As the percentage of female faculty increased, the odds of the influence of cumulative GPA on persistence decreased. Similarly, the interaction between URM faculty and cumulative GPA (*OR* = 0.98, $p < .044$, 95% CI [0.98, .1.01]) was found to have a significant effect on the persistence of engineering transfer students. As the percentage of URM faculty increased, the odds of the influence of cumulative GPA on persistence decreased. Additionally, the interaction between average class size and cumulative GPA (*OR* = 0.96, $p < .048$, 95% CI [0.96, 1.00]) was found to significantly affect engineering transfer students' persistence. As the average number of college/department of engineering class size increased, the odds of the influence of cumulative GPA on persistence decreased.

While the interaction terms were statistically significant, the odds ratios were all close to 1.00. Given that the odds ratios were close to 1.00 and the large sample size, it was determined that probing the interaction terms was not necessary.

Summary

This chapter presented the results of the descriptive, multiple linear regression, and logistic linear regression analyses of 4,163 students who vertically transferred to universities within the UNC System with engineering or engineering technology programs. The transfer students in this study were predominantly White (68%) and men (89%). Engineering (53%) and engineering technology (47%) students were similarly represented in the sample. Most of the sample were Pell Grant eligible (59%), which was used as a proxy for socioeconomic status.

The descriptive statistics suggested differences in first-semester academic success, as measured by first-term GPA, by sociodemographic subpopulation. White transfer students earned a significantly higher first-term GPA than Black or African American students. Non-traditional age students achieved a higher first-term GPA than traditional age students. Additionally, AAS completers earned, on average, higher first-term GPAs compared to students who did not complete an associate degree or attained an AA, AFA, AGE, or AS degree. These differences narrowed when comparing the cumulative GPAs of engineering or engineering technology persisters by subpopulation. However, White students had a significantly higher cumulative GPA than Black or African American students of the students who persisted.

When disaggregating the sample by AAS and AS degree types, 90% of AAS completers pursued engineering technology majors while 93% of AS completers pursued engineering majors. Of the AAS completers, 35% of engineering technology students persisted to an engineering technology baccalaureate degree, and 45% of engineering majors earned an engineering baccalaureate degree. For AS earners, 71% of engineering technology students persisted in engineering technology baccalaureate degrees, and 62% of engineering majors earned engineering baccalaureate degrees. These findings suggest that the AS degree pathway better prepares engineering and engineering technology for the baccalaureate.

Transfer credit inefficiency was discovered from the descriptive statistics. On average, engineering persisters had 60 transfer credit hours applied to their baccalaureate upon transfer; however, their cumulative hours earned in higher education exceeded 150 hours. From 2009 to 2016, the majority of the undergraduate engineering degrees offered at the institutions included in this study required fewer than 130 hours of credit to complete. This finding suggests that while the RIs accepted the transfer credit, many transferred credits did not apply toward engineering coursework. Excess transfer credits were further evidenced by the average time to graduation. On average, engineering or engineering technology persisters took 6.5 semesters to complete the remainder of the baccalaureate coursework at the receiving institutions. While the dataset did not include the time spent at community colleges, there is evidence that the excess transfer hours contributed to prolonged time to graduation and increased financial burden for these students.

Results of the multiple linear regression models indicated that the model accounted for the most variance when Smith and Van Aken's (2020) three categories (student-influenced factors, institution-influenced factors, and factors influenced by both student and institution) of engineering transfer student persistence were included. The model suggests that academic success during the first term at the RI depends on student background, pre-transfer academics, institutional characteristics, and hours attempted and earned during the first term. The variance accounted for in first-term academic success was moderate with $R^2 = .325$. Race/ethnicity, age, applied transfer hours, percentage of female faculty members in the college/department of engineering, first-term attempted hours, and first-term earned hours were significant predictors of first-term GPA.

The multiple linear regression model with the addition of interaction terms between institutional-influenced factors and applied transfer hours was statistically significant; however, the variance only increased by .002. The interaction between female faculty and applied transfer hours was statistically significant and was probed further with simple slope plots. The plot indicated that the influence of applied transfer credit on first-term GPA was more at institutions with more female faculty.

The logistic regression models revealed that the full model with all student and institutional predictors was statistically significant, which indicated that the variables reliably predicted the students who persisted and those who did not. The variance accounted for persistence or degree attainment was high, with Nagelkerke $R^2 = 66.6\%$. The model correctly classified 94.5% of those who persisted and 74.8% of those who did not for an overall correct classification rate of 87.1%. Age, applied transfer hours, associate degree types, female faculty, URM faculty, average class size, cumulative GPA, and total hours earned at the RI were significant predictors of persistence to engineering or engineering technology baccalaureate degree.

The logistic regression model with the addition of interaction terms between institution-influenced predictors and cumulative GPA was statistically significant; however, the addition of these terms modestly increased the variance accounted for in persistence (Nagelkerke R^2 = 67.2%). The model correctly classified 94.9% of those who persisted and 74.8% of those who did not for an overall correct classification rate of 87.4%. All interaction terms were found to be statistically significant; however, since the odds ratios were close to 1.00, the interaction effects were not probed further.

CHAPTER 5: DISCUSSION

The purpose of this study was to examine the relationship between student demographic characteristics, academic performance, and college/department of engineering environment in predicting the academic success and persistence of engineering students who transferred from two-year institutions. This chapter discusses the study's results relative to its purpose, prior research on engineering transfer students, and methodology. Limitations of the study, implications and recommendations for research, policy, and practice are also presented.

Overview of the Present Study

Two-year institutions are a vital pathway in meeting the demand of a highly qualified STEM workforce (Hoffman et al., 2010) and serve as a means in broadening the participation in professional careers, such as engineering, that have been historically overrepresented by White men. Community college students are more likely to be students of color, women, first-generation, veterans, and older than students who matriculate directly from high school to four-year institutions (AACC, 2021). Moreover, strengthening the vertical transfer pathway to engineering disciplines can improve equity by increasing the social and economic mobility of this diverse subpopulation of students (Dowd, 2012; Terenzini et al., 2014). However, there is empirical evidence that points to differences in the retention and graduation rates between vertical transfer students and UNC System first-time, first-year (FTFY) students (D'Amico & Chapman, 2018).

The literature on engineering transfer student success and baccalaureate degree attainment remains sparse. Smith and Van Aken's (2020) systematic review on the persistence of engineering transfer students found that the research predominately focused on pre-transfer academic outcomes or, more broadly, on STEM transfer students. Due to the shortage of knowledge, further empirical research is necessary to determine how institutional context at receiving institutions either promotes or detracts from the academic performance and the persistence of engineering transfer students. Understanding the institutional characteristics experienced by vertical transfer students in engineering majors at four-year institutions is crucial in understanding the overall adjustment of transfer students. Furthermore, identifying factors that affect academic success and persistence is necessary to facilitate the development of more inclusive policies, student support services, and departmental programming tailored to the unique needs of this student population (Smith & Van Aken, 2020).

To address this gap in the literature, a correlational study was conducted using secondary, longitudinal data to examine the first-semester academic success and persistence of vertical transfer students who pursued a baccalaureate engineering degree in the UNC System from 2009 to 2016. The sample included 4,163 students who transferred from a community college to one of the five UNC System institutions that offered baccalaureate engineering degrees: ECU, NC A&T, NC State, Charlotte, and WCU. Additionally, the moderating effects of the college/department of engineering characteristics on the relationship between post-transfer credit hours and first-term GPA and between post-transfer academics and baccalaureate degree completion were investigated.

A modified version of Smith and Van Aken's (2020) literature-based conceptual framework on engineering transfer student persistence guided the study. Smith and Van Aken assert that the persistence of this student population is a function of three categories of factors: student-influenced, institution-influenced, and factors considered to be influenced by both student and institution. In this study, persistence is designated as baccalaureate engineering or engineering technology degree completion. The variables included in the study were informed by a review of the literature on engineering transfer student persistence.

Based on the structure of these data, regression modeling was used to investigate the effects of student characteristics, academic outcomes, and institutional characteristics to predict first-term GPA and degree completion. First, a multiple linear regression model was constructed by entering the variables into the model in three blocks. Multiple linear regression demonstrated that the variances in first-term GPAs at the receiving institutions were a function of student and institutional characteristics. Results from multiple linear regression analyses suggest that (a) Black or African American and Hispanic students had significantly lower predicted first-term GPAs than White students, (b) non-traditional age students had a significantly higher predicted first-term GPA than traditional-age students, (c) an increase in applied transfer credit hours significantly predicted an increase in first-term GPA, (d) an increase in the percentage of female faculty members significantly predicted an increase in first-term GPA, (e) an increase in attempted credit hours during the first-term significantly predicted a decrease in first-term GPA, and (f) an increase in earned credit hours significantly predicted an increase in first-term GPA.

Applied transfer hours and the interaction terms between the percentages of female and URM faculty and average class size were added to the multiple linear regression model in a fourth block. Multiple linear regression analyses indicated a minimal increase in the variances in first-term GPAs. Results suggest that the percentages of female and URM faculty moderated the effect of applied transfer hours on first-term academic success. At institutions with a higher representation of women in their faculty, the influence of applied transfer credit hours on first-term GPA was greater. Further probing of the interaction between URM faculty and applied transfer hours found negligible differences between institutions with lower or higher percentages of URM faculty in the influence of applied transfer hours and first-term GPA.

Logistic regression analyses demonstrated that engineering or engineering technology baccalaureate degree completion was a function of student and institutional characteristics. Results from the block entered logistic regression analyses suggest that (a) the gender and race/ethnicity of a student did not significantly impact the likelihood of engineering/engineering technology degree attainment, (b) traditional-age students were significantly more likely to earn an engineering/engineering technology degree compared to non-traditional-age students, (c) students with more applied transfer credit hours were significantly more likely to earn an engineering/engineering technology degree compared to students with less applied transfer credit hours, (d) students who earned an associate degree were more likely to earn an engineering/engineering technology degree compared to students who did not earn an associate degree, (e) first-term GPA did not significantly increase the likelihood of persistence, (f) students who had higher cumulative GPAs were significantly more likely to persist, (g) students with more earned hours at the receiving institution were significantly more likely to persist to degree attainment, and (h) the total number of semesters spent by the student at the receiving institution did not significantly increase the likelihood of persistence.

The interaction terms between the percentage of female faculty, percentage of URM faculty, average class size, and cumulative GPA were added to the logistic regression model in a fourth block. Logistic regression analyses indicated a minimal increase in baccalaureate degree completion variances. Results suggest that the percentage of female faculty, percentage of URM faculty, and average class size moderated the effect of applied transfer hours on first-term academic success. However, further probing of the interaction these college/department of engineering characteristics and cumulative GPA was deemed inappropriate since the odds ratios for each interaction term were close to 1.00.

The following sections discuss the descriptive and inferential statistics, and discussions are offered regarding the findings. The present study results are discussed in relation to the extant literature on the academic success and persistence of vertical transfer students pursuing baccalaureate engineering degrees.

Discussion of Descriptive Data

There were several important findings discovered from the descriptive analyses of these data. Specifically, there were inequities found by the results of the student characteristics statistics alone. The sample consisted of 68% White, 10% Black or African American, 7% Hispanic, 5% Asian, and 10% Other race engineering students—comparing the sample demographics to the fall 2015 enrollment of all public universities in North Carolina, the demographic makeup identified as approximately 61% White, 25% Black or African American, 7% Hispanic, and 3.3% Asian (NCES, 2016). Additionally, there were stark differences when comparing gender. Approximately 11% of the sample identified as women, while women made up 58.1% of the fall 2015 enrollment at public universities in North Carolina (NCES, 2016).

Women, African American, and Hispanic students have been historically underrepresented in engineering education, and this enduring problem is not limited to North Carolina. Nationwide, the demographic backgrounds of FTFY underrepresented students who earned bachelor's degrees in engineering and engineering technologies in the 2015-2016 academic year included 4% African American, 10% Hispanic, and 21% women; while this study consisted of 8% African American, 6% Hispanic, and 11% women persisters. This comparison indicates a higher representation of African American engineering transfer students than the profile of FTFY students, which aligns with the findings of Didion (2015) and Sullivan et al. (2012). However, there is an apparent disparity in the diversity of the sample compared to FTFY students nationwide. This finding contradicts other studies that found a disproportionately higher representation of Hispanic/Latinos and women among engineering transfer students (Didion, 2015; Gibbons et al., 2011; Knight et al., 2014; Terenzini et al., 2014; Yoon et al., 2015).

Inequities were also discovered when comparing first-term and cumulative GPAs between racial subgroups within the sample. The average first-term GPA for White (2.78) students was notably higher than Hispanic or Latino (2.54), Asian (2.54), and Black or African American (2.41) students. While transfer shock was not calculated in the present study (community college GPA was not included in the UNC System Transfer Student dataset), the academic achievement gap during the first semester aligns with extant research by Lakin and Cardenas Elliott (2016). Both studies found that Black or African American students experienced a lower GPA than other racial subgroups. The gap in cumulative GPAs between races/ethnicities narrowed slightly between engineering persisters (e.g., White [3.21], African American or Black [3.00], Hispanic or Latino [3.12], and Asian [3.05]). Findings from this study, coupled with existing literature (Cosentino et al., 2014; Lakin & Cardenas Elliot, 2016), contribute to the national debate regarding equity gaps in higher education. The evidence from this study suggests that structural inequities exist for these students that act as barriers to academic success post-transfer.

The sample was nearly evenly split between traditional and non-traditional age transfer students; however, there was a 0.20-point difference in first-term GPAs between the two subgroups (e.g., traditional, 2.61 and non-traditional age, 2.81). When comparing the percentages of engineering persisters in the sample, 56% of students were 24 and younger, and 42% of students who were 25 and older earned an engineering or engineering technology baccalaureate degree. The gap widens further between the subgroups when including any baccalaureate degree earned, where roughly 61% of traditional and 45% of non-traditional age students completed the baccalaureate. This finding suggests that while non-traditional age students have higher levels of academic success during the first semester, they are less likely to persist to baccalaureate degree attainment. This finding aligns with existing literature on the persistence of non-traditional age transfer students. Non-traditional age students are more likely to have external commitments such as working full-time, caring for dependents in their households, and financial constraints act as barriers to degree attainment (Atwell, 2020; Hirschy, 2011).

In the sample, 50% of White, 42% of Black or African American, 48% Hispanic or Latino, and 53% Asian students completed an engineering or engineering technology baccalaureate. These results suggest that engineering transfer students achieve baccalaureate degree attainment at lower rates than all North Carolina transfer students (D'Amico & Chapman., 2018). D'Amico and Chapman found that 65% of White, 50% of Black or African American, and 63% of Hispanic or Latino vertical transfer students in the UNC System earned a baccalaureate degree. However, when including students that earned any baccalaureate degree, a total of 54% of White, 47% African American or Black, 52% of Hispanic or Latino, and 60% Asian transfer students completed the baccalaureate. This evidence suggests that North Carolina community college transfer students may experience a more difficult transition into baccalaureate engineering programs than other non-engineering fields of study.

The descriptive findings on the institutional characteristics of the receiving institutions in this study align with Smith and Van Aken's (2020) proposed conceptual model that includes institution-influenced factors as an integral component of engineering transfer student persistence. For example, the Carnegie Basic Classification was used to measure the amount of research activity and conferred graduate degrees at each receiving institution in this study. The differences in the students' first-term GPAs according to the institution's Basic Classification were considerable: Master's Universities earned the highest first-term GPA (3.07), Doctoral Universities (2.79), Doctoral Universities- High Research (2.66), and Doctoral Universities- Very High Research (2.55). These results suggest as the amount of research activity increased, the average first-term GPA of transfer students decreased. These findings may reflect differences in grading standards and distributions across the receiving institutions instead of a direct effect on academic performance. However, low first-term GPAs are likely to impact students' confidence and affect their commitment to an engineering or engineering technology degree.

When disaggregating baccalaureate degree completion by Basic Classification, Master's Universities had the highest percentage of degree completion at 61%, Doctoral Universities had 48%, Doctoral Universities with High Research had 45%, and Doctoral Universities had 56%. The gaps in degree attainment narrowed further when including all students who earned a non-engineering or engineering technology degree: 63% at Master's Universities, 51% at Doctoral Universities, 50% at Doctoral Universities with High Research, and 61% at Doctoral Universities with Very High Research. These findings suggest that while students had, on average, lower academic performance during the first semester, the students who persisted were just as likely to graduate from receiving institutions with very high research activity as they were from institutions with modest research activity.

This study provides evidence that engineering and engineering technology transfer students tend to struggle more academically during the first semester at institutions with more research activity. Townsend and Wilson's (2008) study found a disparity between faculty and transfer student expectations at research-oriented institutions. At research-intensive institutions, faculty earn promotion and tenure through their research, grants, and publications instead of teaching, leading transfer students to perceive faculty as more dismissive when approached for help (Vematt et al., 2021; Townsend & Wilson, 2008; Townsend & Wilson, 2006). Thus, one way to mitigate this effect is for receiving institutions to be transparent to prospective transfer students of the norms and academic expectations of each department. Additionally, funding and strengthening transfer-specific student support services are imperative to ease transfer students' transition into learning environments that may differ from their experiences at the community colleges.

Discussion of Regression Models

The present study modeled the academic success and degree completion of vertical engineering transfer students as a function of student and institutional characteristics. The following sections discuss the results for each research question posed by this dissertation. The first two research questions were modeled using multiple linear regression to predict the students' first-term GPA at the receiving institution. Then, the last two research questions were modeled using logistic regression to predict transfer students' persistence.

The predictors were grouped in alignment with Smith and Van Aken's (2020) conceptual model, where Block 1 included student demographics (i.e., gender, race/ethnicity, age, Pell Grant eligibility) and pre-transfer academics (i.e., applied transfer hours and associate degree completion). Block 2 included institution-influenced characteristics of the college/department of engineering (i.e., percentage of female faculty, percentage of URM faculty, and average class size). Block 3 included student-influenced and institution-influenced characteristics, which included a student's post-transfer academics (i.e., attempted and earned credit hours) in the first semester. Lastly, Block 4 included interaction terms related to the research questions.

Research Question 1

How do student and institutional factors predict the academic success of engineering transfer students in their first term at the receiving institution?

Results from multiple linear regression models revealed that several student and institutional factors had a significant impact on first-term academic success. There were both positive and negative effects on first-term GPA when all other predictors were held constant. A student's race/ethnicity and attempted hours had a statistically significant and negative effect on a student's first-term GPA at the receiving institution. While age, applied transfer hours, percentage of female faculty, and earned hours during the first term had a statistically significant and positive effect on a student's first-term GPA. Results from the model indicated no relationship between gender, Pell Grant eligibility, associate degree earners, percentage of URM faculty, and average class size on first-term GPA.

The finding that Black or African American and Hispanic students had significantly lower predicted first-term GPAs than White students is consistent with extant research on transfer student success in STEM majors (see, e.g., Lakin & Cardenas Elliot, 2016). This finding, coupled with the descriptive results, clearly suggests that the transition from community college to four-year institutions is not equitable for racially underrepresented students pursuing engineering baccalaureate degrees. While most engineering transfer students experience some degree of transfer shock (Anderson-Rowland, 2011), existing research suggested that increases in first-term GPA led to increases in persistence in the major (Anderson-Rowland, 2009; Lair & Steadman, 2014; Lakin & Cardenas Elliot, 2016). Conversely, a lower first-term GPA post-transfer can lead students to question their place in engineering or engineering technology majors and ultimately lead to attrition (Laugerman et al., 2015; Laugerman & Shelley, 2013). To broaden the participation in engineering careers, educators and administrators will need to use a multifaceted approach that includes an anti-deficit mindset and targeted student support services. There is evidence that institutions that adapted transfer-specific student support services, activities, and organizations; and intrusive academic advising interventions positively impacted transfer students of color (Anderson-Rowland, 2011; Grites, 2014; Sarder, 2013; Scott et al., 2017).

Non-traditional age students had a significantly higher predicted first-term GPA than traditional age students. For example, there was a predicted increase of 0.13 points on first-term GPA for students who were 24 or older compared to students who were 23 or fewer years old. Unfortunately, extant research on the first-term academic performance of this subpopulation of engineering transfer students remains sparse. Nevertheless, this result is significant when considering that non-traditional age transfer students are more likely to receive financial aid, have dependents in their household, and work full-time. Moreover, these results suggest that while older students likely had more non-academic responsibilities, they had a higher level of first-term academic success compared to traditional age transfer students.

Only one of the pre-transfer academic factors was a statistically significant predictor of first-term GPA. The results suggest that an increase in applied transfer credit hours significantly predicted an increase in first-term GPA. For example, for every 10-hour increase in applied transfer credit hours, there was a 0.03 increase in predicted first-term GPA. This finding is consistent with existing research that the more transfer credit hours an engineering student earned before transferring, the higher academic performance (Anderson-Rowland et al., 2015;

Lakin & Cardenas Elliot, 2016; Lopez & Jones, 2017). Interestingly, completing an associate degree, particularly an AS or AAS, did not significantly predict first-term GPA in this study. This finding contradicts previous research studies that found evidence that associate degree earners had higher persistence rates at four-year institutions (Lee & Schneider, 2016; Lopez, 2012; Mattis & Sislin, 2005); however, these studies did not compare persistence to first-term academic performance.

The proportion of female faculty in the college/department of engineering was the only positive and statistically significant institution-influenced predictor of first-term academic success. An increase in the percentage of female faculty members significantly predicted an increase in first-term GPA. Extant research has suggested that increasing female participation in STEM faculty positively impacts retention rates and increases the number of students reaching the baccalaureate degree (Campbell, 1999; Johnson & Sheppard, 2013). Findings from this study add to existing literature and suggest that increased female faculty representation in engineering colleges contributes to the improved academic performance of transfer students in their first term.

In the student-influenced and institution-influenced factor category, the two post-transfer academic variables were statistically significant. An increase in attempted credit hours during the first term significantly predicted a decrease in first-term GPA. That is, for each one hour increase in attempted credit hours at the receiving institution, the predicted GPA for transfer students dropped by 0.22 points. The converse was true for earned credit hours in the first term. The predicted GPA increased by 0.24 points for each one-hour increase in earned credit hours. Extant research has found that attempting fewer credit hours in the first semester is related to higher persistence rates for this population of students (Anderson-Rowland, 2009; Lair & Steadman, 2014; Lee & Schneider, 2016; Laugerman & Shelley, 2013). These findings suggest that administrators and academic advisors should consider recommending that transfer students attempt fewer hours in their first term.

Research Question 2

How do institution-influenced factors moderate the relationship between pre-transfer academic factors and the academic success of engineering transfer students during their first term at the receiving institution?

To address this question, interaction terms between institution-influenced predictors and applied transfer credit were added to the multiple linear regression model in Block 4. The findings revealed that the proportion of female faculty in the college/department of engineering moderates the relationship between applied transfer hours and first-term GPA for engineering transfer students. Specifically, while the amount of applied transfer credit predicted first-term GPA, this relationship is stronger at institutions with a higher percentage of female faculty in the college/department of engineering. Moreover, increased applied transfer hours were less influential in predicting first-term GPA at receiving institutions with a lower proportion of female faculty. The findings from this study suggest differences in the impact that pre-transfer academics have on first-term academic success based on female faculty representation.

An important caveat to this finding is that the present study did not distinguish whether the transfer students had female engineering instructors during their first semester, only the percentage of female faculty serving in the college/department of engineering at the time. Yet, faculty makeup is an essential component of college/department culture because most engineering students interact with the campus environment exclusively through their engagement in class. Extant research has found that female professors are required to teach more than their male counterparts, insinuating that female instructors may have more interactions with students than the actual percentage of female faculty suggests (Allen, 1997; Retherford et al., 2020). Previous research has demonstrated that female representation in STEM faculties impacts the retention and persistence of students. Still, there appears to be no published research exploring female faculty's impact on engineering transfer students. Further, previous research has suggested that positive relationships with female faculty have been linked to academic performance and persistence of underrepresented students in STEM fields (Carrell et al., 2010).

Research Question 3

How do student and institutional factors predict baccalaureate engineering degree attainment of transfer students?

The third and fourth research questions were modeled using logistic regression with hierarchical blocks to predict first-term GPA. Blocks 1 and 2 included the same variables as the multiple linear regression models. Block 3 consisted of characteristics that were considered to be influenced by both the student and the institution which were measured by a student's post-transfer academics (i.e., first-term attempted hours, first-term GPA, total semesters at the RI, cumulative GPA, and total hours earned at the RI).

Results from the logistic regression analyses revealed that the persistence of engineering transfer students is a function of student and institutional factors. There were positive and negative effects on persistence when all other predictors were held constant. A student's age, faculty demographics, and average class size had a statistically significant and negative effect on persistence to the baccalaureate at the receiving institution. While applied transfer hours, associate degree type, cumulative GPA, and total earned hours at the receiving institution had a statistically significant and positive effect on persistence. Results from the model indicated no relationship between gender, race/ethnicity, Pell Grant eligibility, first-term GPA, first-term attempted hours, and total semesters at the receiving institution on baccalaureate degree attainment. The logistic odds ratios were provided to explain the unique contribution of each significant predictor.

Of particular interest from the model was the finding that a student's gender, race/ethnicity, and socioeconomic status did not significantly impact the likelihood of engineering/engineering technology degree attainment. Specifically, underrepresented transfer students in this study were just as likely as White men to persist to the baccalaureate. This finding, coupled with descriptive statistic results, is consistent with the findings of Lakin and Cardenas Elliott (2016). They found that while Black or African American and women engineering transfer students had lower first-term GPAs than their White, male counterparts, they were just as likely to persist. A surprising but similar finding to Lakin and Cardenas Elliot's (2016) work is that first-term GPA was not a statistically significant predictor of persistence or degree attainment. It may be that all students in the sample experienced a substantial dip in first-term GPA compared to their academic performance at the community college, and it is no longer a significant factor in explaining departure from the major. More, it is plausible that merely completing challenging gateway courses in their major increased their resilience and served as an impetus for students to further their commitment to engineering or engineering technology.

There was a statistically significant and negative association between age and the probability of persistence or baccalaureate degree attainment. Traditional age transfer students were significantly more likely to earn an engineering/engineering technology degree compared to non-traditional-age students. Specifically, the odds of persistence among students who were 23 or younger were 1.41 times more likely versus the odds of 24 and older students. While the literature related to age and persistence of engineering transfer students remains sparse, this finding is consistent with extant research on transfer students in general. Wolzinger and O'Lawrence (2018) found that non-traditional age transfer students were less likely to persist in career and technical education pathways than their traditional age counterparts. This finding, coupled with the results of the descriptive statistics, suggests that while older transfer students have higher levels of academic performance in the first term, they encounter additional barriers to the baccalaureate.

Students with more applied transfer credit hours were significantly more likely to earn an engineering/engineering technology degree compared to students with less applied transfer credit hours. In particular, the odds of a student earning a baccalaureate engineering or engineering technology degree increased by a factor of 1.17 with every 10-hour increase in applied transfer hours. Additionally, the present study found that transfer students who earned an associate degree were more likely to earn an engineering/engineering technology degree than students who did not. These findings were expected given the literature on academic preparedness of engineering transfer students (Anderson-Rowland et al., 2015; Lakin & Cardenas Elliot, 2016; Lee & Schneider, 2016; Lopez & Jones, 2017; Mattis & Sislin, 2005).

While any associate degree type increased the probability of persistence, there were differences among degree types. Specifically, the odds of persisting among AAS and AS degree earners persisting was 2.44 and 1.95 times greater, respectively, than the odds of students who did not earn an associate degree. These findings were unsurprising given that most AAS degree earners pursued a baccalaureate engineering technology degree which is typically closely aligned. Similarly, most AS degree earners pursued a baccalaureate engineering degree which is comparably aligned. However, a surprising finding was that the odds of AA, AFA, or AGE earners persisting was 2.02 times greater than the odds of a non-associate degree earner obtaining a baccalaureate degree. AA, AFA, and AGE degrees generally do not require advanced mathematics or science courses such as Calculus 1, Calculus 2, or Physics 1. This finding is unexpected given the literature on the importance of completing these courses before transfer in the persistence of engineering transfer students (Darrow, 2012; Laugerman et al., 2015; Laugerman & Shelley, 2013). These findings provide evidence that persistence to an associate degree is related to persistence to baccalaureate degrees. It is plausible that the act of completing an associate degree prompted resilience and confidence in these students regardless of the classes completed at the community college.

The finding that cumulative GPAs and the number of earned hours at the receiving institution were associated with baccalaureate degree attainment is consistent with the literature on engineering transfer student success (Lakin & Cardenas Elliot, 2016; Lee & Schneider, 2016). In the present study, the likelihood of a transfer student earning a baccalaureate degree increased by a factor of 3.69 for each point increase of cumulative GPA. Both results were not surprising; however, an unexpected finding was that the total number of semesters spent at the receiving institution did not significantly increase the likelihood of persistence when all other predictors were held constant. It was hypothesized that more time spent at the receiving institution would have predicted persistence for these students; however, this was not evident from the current study. These findings suggest that higher levels of academic performance (i.e., GPA and successful completion of coursework) were more influential in predicting the probability of persistence than time spent at the receiving institution.

Research Question 4

How do institution-influenced factors moderate the relationship between post-transfer academic factors and baccalaureate engineering degree attainment?

To address this question, interaction terms between institution-influenced predictors and cumulative GPA were added to the logistic regression model in Block 4. The findings revealed that the percentage of female and URM faculty and average class size in the college/department of engineering significantly moderated the relationship between cumulative GPA and degree attainment for engineering transfer students. However, the odds ratios for each interaction were close to 1.00, which indicated that the institution-influenced predictors had a minimal effect in moderating the relationship between cumulative GPA and the outcome. These results showed that institutional factors, such as faculty makeup and average class size, do not meaningfully moderate the effect of cumulative GPA on persistence in engineering or engineering technology.

Extant research on the impact of faculty makeup on the persistence of engineering transfer students remains sparse. However, multiple studies have found that faculty interactions are a strong indicator of persistence (Allen & Zhang, 2016; Anderson-Rowland, 2011; Dika et al., 2020; Jackson & Laanan, 2015; Sheinberg, 2015). In addition, recent studies have highlighted the importance of minoritized students having faculty role models from similar cultural or ethnic backgrounds in their success (Museus & Liverman, 2010; Suitts, 2003; Lent et al., 2005). However, the results from the present study may align more closely with Cole and Espinoza's (2008) work. They found that supportive and accessible engineering professors, regardless of ethnicity, were a factor in students' academic success and persistence in the major.

Similarly, literature on the influence of class size on the academic success and persistence of engineering transfer students is meager, though it has been cited as a factor in the differences in students' academic integration between two-year and four-year institutions (Bryant, 2001; Crisp & Mina, 2012; Evans & Mody-Pan, 2010). Vertical transfer students typically come from an environment with more individualized attention and one-on-one interactions with faculty since community colleges tend to offer smaller class sizes. Fematt et al. (2021) suggested that issues with student integration at large research universities were likely due to classes being held in large lecture halls, limiting opportunities for faculty-to-peer and peer-to-peer interactions. Moreover, transfer students have expressed large class settings as intimidating, which suppressed in-class interactions and participation (Roberts & McNeese, 2010; Townsend & Wilson, 2006). However, the present study did not find average class size as a meaningful moderating effect on academic success (i.e., cumulative GPA) and persistence. An important note about the present study is that the average class size variable did not include the actual average class size experienced by the transfer student, only the average class size of all courses taught in the college/department of engineering. Anecdotally, class sizes tend to be larger in the first and second year of engineering curriculums and decrease as students take major-specific and technical elective courses.

Limitations of the Study

There are several limitations to this study. First, since secondary data were used, the variables and variable definitions are limited to those included in the UNC System Transfer Student dataset. For example, the amount of math, science, and engineering courses completed by the student before transfer are not included in the dataset. Satisfying these course requirements impacts the amount of transfer credit hours applied to baccalaureate engineering degrees. Applied transfer credit contains general education courses or other courses that are not required for undergraduate academic plans of study for engineering. Conversely, several variables included in the UNC System Transfer Student dataset were excluded from the study. For example, citizenship, in-state/out-of-state indicator, high school GPA, and the number of associate degrees completed were excluded.

Pell Grant awarded was used as a proxy for socioeconomic status, a common measure of socioeconomic status in higher education research. Inferences about socioeconomic status in this study were determined from the *Pell Grant* variable alone. Moreover, the variable indicated whether a student was ever Pell Grant eligible during their time at the receiving institution. The income, education, occupation, and other scholarship or grants awarded to each student were unknown, which could have impacted their socioeconomic status.

Additionally, all engineering and engineering technology majors were treated the same in the study. While engineering and engineering technology students were combined, departmental experiences could differ. For example, many of the receiving institutions in this study have a college of engineering that consists of multiple departments based on engineering discipline. Therefore, faculty demographics and class size could differ per department, potentially affecting this population's academic performance and degree attainment.

This study included transfer students admitted between 2009 and 2016. The UNC System Transfer Student dataset was compiled in the spring semester of 2021, so limiting the entry date to 2016 allowed for up to 8 academic semesters for the transfer student to graduate. However, transfer students in the 2016 cohort may graduate in 2021 or are on track to graduate with a baccalaureate degree in engineering later. Similarly, students who transferred in 2017 or later could have graduated by fall 2020 but were not included in this study.

The present study did not differentiate between in-state and out-of-state vertical transfer students. However, there may be differences in the experiences and academic outcomes between these two subpopulations transfer students.

Lastly, this study did not account for motivation, interactions with faculty and peers, the number of hours worked per week, degree goals, and commitments of transfer students. Yet, these factors are predictors of academic performance and persistence and were included in Smith and Van Aken's (2020) conceptual model.

Implications and Recommendations for Research

Results from this study offer several implications and recommendations for research. First, this study contributes to the research on engineering transfer students by using advanced statistical methods to explore statewide, longitudinal data. Multi-institutional or statewide samples allow for a greater understanding of how higher education system structures within states promote or detract from the persistence of engineering transfer students. Specifically, this study yielded findings that can better help to understand how differences in college/department of engineering environment (i.e., Carnegie Classifications and college/department of engineering's faculty makeup and average class size) impact students' academic success during the first semester and their persistence to baccalaureates. Additional research could explore other college/department of engineering characteristics such as differences between engineering disciplines; student involvement in student organizations, co-ops, internships, and undergraduate research opportunities; and advising practices that could influence the persistence of these students.

Next, this study presents evidence that engineering transfer student persistence is a function of three categories of factors: student-influenced, institution-influenced, and those considered both student and institution-influenced. This finding supports Smith and Van Aken's (2020) conceptual model, adapted from Tinto's Theory of Integration, that the researchers modified to include more inclusive factors affecting engineering transfer students' persistence. In addition, this study provides evidence that the conceptual model is also applicable to first-semester academic performance. While controlling for all other variables, this study revealed variables from each category that had a statistically significant association with first-term academic success and persistence. Future research utilizing Smith and Van Aken's (2020) conceptual model should consider a mixed-methods approach to incorporate the perspectives of transfer students as they navigate the transition process and engage with the college environment. Using a mixed-method design may shed more light on the inequities experienced by students of color in the engineering transfer pathway than a solely quantitative or qualitative study.

This study found that students who earned an AA, AFE, AGE, AAS, or AS degree before transfer were at least twice as likely to persist to the baccalaureate compared to non-associate degree completers. It should be noted that a new associate degree and pathway specifically for engineering transfer students were not included in the study. In 2015, an articulation agreement between the UNC System and North Carolina Community Colleges offering an Associate in Engineering (AE) was approved to create a new transfer pathway into engineering called the Engineering Pathway program (NCCCS, 2015). In 2019, 72 students represented the first cohort of AE completers who transferred to UNC baccalaureate engineering programs. According to the UNC System Interactive Dashboard, five of these students graduated with a baccalaureate degree within two years after matriculating. Future research can use a similar research design as the present study to explore the academic success and persistence of students participating in the Engineering Pathway program.

Examining different transfer pathways is another critical area for future research. Lateral transfer students, or students who transfer from another four-year institution, are becoming a more significant subpopulation of transfer students. The National Student Clearinghouse Research Center found that vertical transfers are no longer the predominant transfer pathway (Shapiro et al., 2018). Smith et al.'s (2021) single-institution study found differences between lateral and transfer engineering students, particularly when comparing in-state and out-of-state transfer students. A similar research design could be utilized to examine the differences between transfer pathways at UNC System receiving institutions that offer baccalaureate engineering degrees. With the inclusion of institutional factors, the future study will aid in understanding how institutional context contributes to differences in academic outcomes between lateral and vertical engineering transfer students.

Lastly, student background variables such as gender, race or ethnicity, and Pell Grant eligibility were looked at independently in this study. The interconnectedness, or intersectionality (Crenshaw, 1986), between these social characteristics, were not explored in this study but are worthy of future research. Due to the low participation of some students with multiple underrepresented identities (e.g., African American, Hispanic, or Native American women) in engineering education, the limited research in this area has overwhelmingly focused on qualitative methods. However, Cosentino et al. (2014 et al.) utilized the multi-institution, multi-state MIDFIELD dataset to examine the educational outcomes of Black engineering transfer students at 11 institutions and found differences among men and women. By utilizing national datasets, further quantitative research should explore how institutional context impacts the academic experiences and persistence of engineering or engineering technology transfer students with multiple underrepresented identities.

Implications and Recommendations for Policy and Practice

This study has several implications for policy and practice, particularly for institutions that want to increase student success and reduce time to graduation for all engineering transfer students. The findings show that underrepresented students of color experienced lower first-term GPAs at the four-year transfer institutions included in this study. These findings suggest that faculty, academic advisors, and other student services personnel working with transfer students of color consider using a multifaceted approach that includes an anti-deficit mindset and targeted student support services. Further, administrators and college personnel should inform transfer students of possible changes in academic culture (e.g., faculty expectations, grading standards, the pace of instruction, and course norms) through transfer-specific orientation and transfer-specialized advising. College administrators and personnel may consider requiring transfer students to participate in mentoring programs established at the beginning of the semester to normalize the use of student support services offered at these campuses. Additionally, internal assessments of transfer student support programs should be considered to aid administrators and program directors in understanding the effectiveness of the programming on academic outcomes.

Further research is necessary to study barriers and opportunities for older engineering transfer students. This study found that transfer students that were 24 or older had markedly lower levels of persistence even though they exhibited higher levels of academic performance in their first semester post-transfer. The findings suggest that college administrators and personnel explore ways to ease some barriers that non-traditional age transfer students face in their pursuit of advanced engineering degrees. A few recommendations related to relieving some of the financial and childcare responsibilities that many older students experience include creating targeted on-campus student employment, offering courses and student support services in the late afternoon or evening, and on-campus childcare.

Finally, the findings from this study are promising for community college students who pursue advanced engineering degrees in the UNC System. The results suggest that while transfer students may experience a drop in GPA during their first semester, their academic performance in the first semester does not predict their persistence to advanced engineering degrees. Further, the findings provide evidence that transfer students with more transfer credit accumulations experience higher first-term GPAs and are more likely to persist to an engineering or engineering technology baccalaureate. However, on average, the students in this study had 60 hours of applied transfer credits (or 20 hours of transfer credit excess) and spent three and a half years at the receiving institution. College administrators may want to consider implementing transfer-specialized advising by engineering discipline and evaluating critical courses that impact time to graduation. Critical courses should be offered every semester (including the summer, if possible) to optimize the time to graduation for these students. Additionally, the receiving institutions in this study should identify and communicate with the community colleges where most of their vertical transfer students are matriculating to make sure that community college advisors are aware of critical first and second-year mathematics, science, and engineering courses required for advanced engineering degrees. A recent study at Virginia Polytechnic Institute and State University by Richardson and Knight (2022) found differences in excess credits between engineering disciplines, transfer types, and Virginia Community Colleges. Future research on UNC System engineering institutions, should investigate how institutional context impacts transfer credit inefficiency between engineering disciplines, transfer types (i.e., lateral versus vertical, in-state, and out-of-state), differences between North Carolina community colleges, and North Carolina community colleges versus out-of-state community colleges.

Concluding Remarks

Community colleges increasingly serve as an essential starting point for many students who pursue advanced engineering degrees in North Carolina. While first-term academic performance has been part of the literature on transfer students, the research on the combination of student and institutional context characteristics that impact educational outcomes and persistence of engineering transfer students remains sparse. This study shows that inequities exist for Black and Hispanic transfer students in their first semester at the receiving institution. Yet, these students are just as likely to earn an engineering or engineering technology baccalaureate degree. Moreover, the results from this study are promising for vertical engineering transfer students. Transfer students with more community college credits earned higher first-term GPAs and had higher levels of persistence which provides evidence in support of completing an associate degree before transferring.

Regression analyses also showed that first-term academic performance and persistence are a function of student background, pre-transfer educational outcomes, college/department of engineering characteristics, and post-transfer academic performance. Since first-term academic performance and persistence vary by student and institutional factors, this research provides essential information for policymakers, educators, and college professionals seeking to better understand the vertical transfer pathway for engineering students. Additionally, this research offers opportunities for future research and recommendations for targeted interventions that could foster successful student outcomes. Given the increasing use of the vertical transfer pathway to engineering careers, empirical research must continue to bridge the gaps in the literature to improve the transition, student integration, and reduce the time to baccalaureate degree completion of engineering transfer students.

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