Summer 8-23-2023

Comparing Polytechnic and Liberal Arts Institutions: Leaks in the System

Ryan Drew Baldwin
ryan.baldwin@student.shu.edu

Comparing Polytechnic and Liberal Arts Institutions: Leaks in the System

By

Ryan Drew Baldwin

Dissertation Committee

Manuel Gonzalez, Ph.D., Mentor

Jennifer Timmer, Ph.D.

Grace Gangitano, Ph.D.

Submitted in partial fulfillment of the

Requirements for the degree

Doctor of Philosophy

Department of Education, Leadership, Management, and Policy

Seton Hall University

2023

SETON HALL UNIVERSITY 1856

College of Education and Human Services

Department of Education, Leadership, Management, and Policy

APPROVAL FOR SUCCESSFUL DEFENSE

Ryan Baldwin has successfully defended and made the required modifications to the text of the doctoral dissertation for the Ph.D. during this Spring semester.

DISSERTATION COMMITTEE

Mentor	Date
Dr. Manuel Gonzalez	8/23/2023
Committee Member	Date
Dr. Jennifer Timmer	8/23/2023
Committee Member	Date
Dr. Grace Gangitano	8/23/2023
Committee Member	Date

Abstract

The United States has long been a pioneer in higher education, yet the last few decades have proven challenging in maintaining its lead in the science, technology, engineering, and mathematics fields (STEM). Students entering postsecondary education and participating in a STEM degree face increased academic rigor and this study's goal is to better understand factors that influence their retention. There are many psychosocial, environmental, and academic variables that may impact a student's retention and this study aims to investigate how those variables inform a students likelihood of being retained and if there are meaningful differences between polytechnic and non-polytechnic institutions.

Keywords: STEM, polytechnic, retention, remediation, engineering, higher-education pipeline

Acknowledgements

This dissertation could not have been completed without all the support, love, and encouragement from friends, family, colleagues, and of course my committee. I am so thankful to have had the opportunity and support of family and friends who were patient with my schedule while I worked to complete this research project. Furthermore, to have colleagues who regularly checked-in and genuinely appreciated my progress was also a great motivation along with the guidance and mentoring of Manuel Gonzalez, Jennifer Timmer, and Grace Gangitano. Finally, to be able to share this milestone with my grandmother, the original investigator of my family, has truly been a special experience that I am grateful for.

Dedication

I dedicate this work to everyone who supports students pursuing their goals and dreams within the science, technology, engineering, and mathematics fields. Moreover, I dedicate this research to the students themselves who are engaging with STEM studies and wish them all the best in their future.

I also dedicate this dissertation to my late grandfather who years ago, got his degree in mechanical engineering; He worked throughout the day and took classes at night with the encouragement of the veterans he had befriended, all trying to build the next chapter of their lives. There were countless opportunities for my grandfather to "leak" out of the pipeline, but he had a network of friends, dedication to his family, and resiliency to help get him to graduation. He often serves as a reminder for just how much goes into building a successful future.

With love, respect, and kindness.

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Chapter 1

Introduction

Background and Problem Statement

Throughout the history of the higher education system in the US, there has been a theme of expanding access to the masses (Bastedo et al., 2016; Thelin, 2017). While this expansion may have had positive effects on society, not every college student is a product of a high-quality K-12 education (Bolick, 2017; Greene & Forster, 2003). Naturally, higher education must adapt to the expanding diversity of students in regard to their level of academic preparedness for postsecondary education (Greene & Forster, 2003; Woods et al., 2018). By the early 2000s, nearly three out of every four first-year students began their university education in a remedial course (Prasad et al., 2000). More recent data indicates that, about one third of students entering a 4-year institution participate in remedial education (Chen, 2016). With students entering college with varying levels of academic preparedness, institutions of higher education have been challenged to add resources and programs aimed at helping these aforementioned students to achieve success in college level courses, with the longer-term goal being that these students will reach graduation.

There is increasing demand for graduates of science, technology, engineering, and mathematics (STEM) programs in the professional workforce (Bettinger & Long, 2008; Freeman et al., 2014; Gonzalez & Kuenzi, 2012; Parsad et al., 2000). STEM professionals work in a variety of industries and are critical not only to the economic system but, more importantly to solve many of society's problems (i.e., infrastructure, green energy, climate change, food production, etc.; Gonzalez & Kuenzi, 2012). As demand is expected to grow at 1.7 times faster for STEM employment compared to non-STEM over the next couple of years (Ortiz & Sriraman, 2015), the issue of underprepared students struggling to be academically successful and graduate from undergraduate STEM programs will continue to be a growing problem unless otherwise remedied. Many would argue that one of the main expectations of higher education is to educate and graduate productive members of our society; US Congress passed the Servicemen's Readjustment Act of 1944, with a goal to offer financial and educational support to war veterans who needed to be reintegrated into society and join the workforce (Kowalski, 2016; Thelin, 2017). Therefore, if the purpose of higher education is to educate and graduate productive members of society, then universities have an inherent responsibility to address the issue of underprepared students entering the system.[1]

The United States (US) has invested considerable resources and efforts to improve the pipeline of students entering the science, technology, engineering, and mathematics (STEM) programs as it struggles to close the gap between workforce demand and workforce supply (Bettinger & Long, 2008; Park et al. 2018). There was an increase in degrees awarded, though likely due to an increase in enrollment; in 2018-2019 academic year yielded over 472,000 STEM degrees, which is over twice the number from 20-years prior (National Center for Educational Statistics (NCES), n.d.). That being said, non-STEM awards greatly outpace STEM awards: In 2018-2019 over 1.76 million non-STEM degrees were awarded (NCES, n.d.). These numbers indicate that while there are some gains being made in STEM degrees awarded, this cohort remains disproportionately smaller than the non-STEM cohort.

One challenge that the STEM population faces has been at the entry point of postsecondary education. Students who enter college and are underprepared for the academic rigors are enrolled in remedial courses whose curricular goal is to fill in the educational gaps in a

[1]The K-12 system, which prepares students for higher education, bears responsibility as well. However, that topic is outside the scope of this study.

student’s knowledge and skillset. While remedial courses in mathematics and English composition are often a helpful step for students to develop foundational knowledge, all too often this strategy ensures students pay for courses that do not count towards their degree, delay their time to graduation, and can even serve as a deterrent to continue further in their respective program (Bettinger & Long, 2008; Park et al. 2018). While there is an emerging trend to offer remedial courses as corequisites with program required courses, this has not yet reached a national level. Until new academic support and intervention strategies are proven to be more impactful and effective, it is critical to understand the characteristics of who exactly is benefitting from the remedial education process and why. If we know more about who specifically can benefit from remedial education, policymakers and educators may be better suited to make intervention and curriculum changes that further improve effectiveness of remedial education.

While remedial education may support student retention for some but not others, there are theories about who is falling out of STEM programs and why. Although originally applied to women in the STEM field, the leaky pipeline theory can apply to other populations that are underrepresented in STEM as well (Blickenstaff, 2005). This can include other minorities such as African Americans, Hispanics, and other students of color who are not often represented both in the STEM classroom or workplace. These opportunities for leaks are also prevalent among first-generation college students. Prior research has shown that first-generation college students often face additional challenges in postsecondary education than their continuing education student and as a result, they are more vulnerable to changing their mind, major, or postsecondary plans altogether (Padgett, et al., 2012).

With the number of resources dedicated to improving the STEM pipeline, it is necessary to know how those students in the pipeline are performing and if the students are ultimately reaching graduation. National data indicates that less than half of first-year STEM students complete their degree (Chen, 2013). From students, faculty and staff, to policymakers, all can benefit from a deeper and more refined understanding of important connections between characteristics and variables that promote STEM student retention and degree attainment. Attainment is defined here as a student who began a STEM degree program and completed it within six years and retention is defined as term-by-term enrollment within the STEM pipeline.

Allocating monetary and non-monetary resources more effectively and efficiently can improve the STEM pipeline and help our nation's students, institutions, and communities at large. As the STEM pipeline has seen growth in student enrollment in recent years, it continues to see disproportionately low enrollment and degree completion. Meanwhile the President's Council of Advisors on Science and Technology (2012) estimates a need for over one million new STEM professionals to help meet the workforce demand over the next decade. Furthermore, the Bureau of Labor Statistics projects a 10.5% STEM workforce increase between 2020 to 2030 (U.S. Bureau of Labor Statistics, n.d.). This challenge places pressure on students, institutions, and society as a whole to maximize performance. In an already academically challenging set of programs, STEM students are struggling to meet national expectations, yet they are not inherently at fault or blame.

Polytechnic Perspective

While science, engineering, mathematics, and technology programs are offered at a range of institutional types, at polytechnic (also known as institutes of technology) STEM programs are the main focus of the institution in both curricula and mission. A polytechnic institution is 4-year public or private institution that has a primary focus on conducting research, offers the majority of degree programs in the STEM fields and offers both undergraduate and graduate programs (Carey, 2015; Our polytechnic advantage, 2021; Polytechnic campus, n.d.). Because polytechnic institutions focus so heavily on STEM programs, they are often heavily invested in for conducting research, offering labs, workshops and industry level technology for students and faculty to engage in (Carey, 2015; Our polytechnic advantage, 2021; Polytechnic campus, n.d.). Some examples of polytechnic institutes around the nation include California Institute of Technology, Cal Poly, Florida Tech, Georgia Tech, Michigan, Technological University, Massachusetts Institute of Technology (MIT), New Jersey Institute of Technology, New York Institute of Technology, Rensselaer Polytechnic Institute, and Virginia Tech (Our polytechnic advantage, 2021). Furthermore, the level of academic rigor is arguably different than at a liberal arts or business university; STEM students often are required to work in labs and with various forms of data (Payton et al., 2017) and hard sciences are less accommodating of best instruction methods (Michael et al., 2018) therefore, it is possible for STEM students to face “tougher” academic expectations. Programs at polytechnic institutions include a balance of liberal arts material however, there is a focus on high level science, math, and technical education necessary for each respective STEM field (Michael et al., 2018; Payton et al., 2017). Due to the structure of curricula, focus and intent of polytechnic institutions, this institutional type may prove to be a critical area of focus.

It is critical to conduct an intentional investigation and analysis of variable relationships specifically for STEM participating students at polytechnic institutions through a conceptual lens that is intended to be used for this context. Polytechnic institutions may attract a unique student profile and this study aims to investigate how students attending a polytechnic campus perform as we assume their experiences will be meaningfully different than that of a student at a non-polytechnic institution. Polytechnic institutions tend to also focus on research, curricular application and technical skills (Carey, 2015; Our polytechnic advantage, 2021; Polytechnic campus, n.d.) therefore by definition are more inclined to offer STEM programs. Institutions have different priorities depending on their size, location, curricula, research funding, and the types of students they serve; it stands to reason that there may be thematic differences in the types of students and the characteristics they have at different types of institutions. A STEM student at a polytechnic university has the potential to have a unique mix of characteristics compared to a liberal arts student at a liberal arts university, or business student, and so on.

Purpose of Study & Research Questions

This study was framed with multiple goals in mind. I sought to understand the student's demographics and their pertinent experiences related to persisting in their education. How these variables impact student retention and persistence at polytechnic institutions may vary from how they impact student retention and persistence at non-polytechnic institutions. As there has been a wealth of discussion and research conducted on student persistence and retention, in general (Bean, 1980; Besler et al., 2018; Blickenstaff, 2005; Braithwaite & Edgecombe, 2018; Burrus et al., 2013; Conrad et al., 2018; Flynn, 2016; Fu & Yue, 2017; Gibson et al., 2020; Green & Sanderson, 2018; Heil et al., 2014; Jones, 2015; King, 2016; Le et al., 2014; Li et al., 2009; Logue et al., 2017; Ortiz & Sriraman, 2015; Riegle-Crumb et al., 2019; Soldner et al., 2012), this study aimed to further understand how students participating in STEM programs at polytechnic institutions perform. Another goal was to earn a clearer understanding on what factors contribute to STEM students leaking out of the pipeline and if there are differences between leaks at a polytechnic institution as compared to a non-polytechnic institution. As research currently primarily focuses on the program type (i.e., STEM) or the Carnegie classification, and not as it relates to the context of a polytechnic campus, I sought to identify and clarify factors associated with student retention, but within the context of institutional type or focus (i.e. polytechnic or liberal arts). Investigating the impact and interaction between specific characteristics of the STEM student population at a polytechnic institution and their retention should help to clarify who needs intervention and where resources can be more effectively dispersed at each type of institution.

Students entering postsecondary education in the STEM field are not earning degrees at comparable rates to other academic fields despite tens of billions of dollars spent annually to improve the academic success for these students (Bettinger & Long, 2008; Chen, 2013; Park et al., 2018). Therefore, the purpose of this study was to examine to what extent factors including student demographics, institutional experiences and academic expectations are related to student retention at polytechnic institutions, to better inform how resources may be spent towards their success. With the aforementioned in mind, below are the research questions (RQ) this study investigated (RQ):

RQ1a: What factors predict STEM students' retention at polytechnic institutions (i.e., Academic Influences, Psychosocial Influences, and Environmental Influences)?

RQ1b: Do these factors differ for students at non-polytechnic institutions?

RQ2a: Does remedial education negatively impact STEM student's retention at polytechnic institutions?

RQ2b: Is there a difference in impact on retention based on the type of remedial course(s) taken (i.e., mathematics vs. English composition)?

This study was conducted using quantitative methods and utilized data collected from the High School Longitudinal Study of 2009 (HSLS:09) conducted by the National Center for Educational Statistics. HSLS:09 is a rich data set that includes helpful variables related to institution type and profile, student demographic characteristics, academic performance and influencing factors like extra curriculars and hours worked. The themes of variables pulled from informed regression models developed to ultimately study STEM student retention at polytechnic institutions. In regard to the theories and framework that guided my study in its variables of interest and provided a lens to understand analysis outcomes, I incorporated the Social Reproduction Theory which is an extension of how an individual's demographics impact their human capital (Jaffe, 2020); Leaky pipeline theory which provides an explanation for students who fall out of higher education (Blickenstaff, 2005); John Beans model of student retention for students outside of the *traditional* college student profile (Bean, 1980). These theories and framework will be discussed in chapter two but as stated earlier, provided context to understand what the data indicates.

Significance of Study

Students in any program of higher education are entitled to reasonably expect the program they were accepted into and enrolled in is reasonably rigorous. Students gravitating towards STEM programs should not be overly shocked at the level of rigor and coursework expected to be mastered. Those who need additional support, however, should be provided support resources and opportunities to improve their chances of success in their academics. Considering the projections for workforce demands and humanity's focus on societal growth and development, paired with the lack of STEM professionals and new graduates there is an urgent need to deeply understand the complex challenges and opportunities that the STEM pipeline is facing. Critically, understanding the impact that institutional type may have, a student's academic and psychosocial influences may play in a STEM students' retention will help policy makers and key stakeholders improve the system overall and better understand how to support STEM students. Deeper understanding on who benefits from remedial education courses and who does not can help key stakeholders decide how to spend resources and target those resources more effectively; for example, we may find that remedial courses have a positive impact on students at non-STEM institutions but perhaps are not particularly impactful at STEM institutions, this could mean that a deeper investigation on the instructional methods, student population, or curriculum format needs to be done in order to improve the impact. These are examples of how this study could provide important insights into what is going on with our nation's STEM students.

Study Organization and Overview

Chapter one of this study was provided to introduce key concepts and outlined important conceptual framework and theoretical perspectives used in my study. Chapter two review the literature on the history and importance of STEM in the US, retention challenges, popular academic intervention strategies before acknowledging research gaps and my research questions. Following the literature review and research questions, Chapter three details and outlines the methodological practices used in this research study. Chapter four covers the data analysis and results before Chapter five where I discuss the limitations and implications of the research findings.

Chapter 2

Literature Review

Introduction

Chapter two outlines and explores the relevant and recent literature as it pertains to the STEM-pipeline in the North American system of higher education. A glaring gap in the body of research for STEM student persistence relates directly to considering the uniqueness of the polytechnic institution and therefore the literature review that follows will address relevant themes and trends STEM students face before being tied back to the polytechnic perspective. First there will be a general overview and contextualization of the STEM pipeline and its importance in American higher education. After reviewing the history of STEM follows a review of the recent trends related to the demographics of students in higher education, STEM programs and their retention and graduation rates, followed by the conceptual and theoretical frameworks that I will used to ground my research. Next, a section exploring the relevant research conducted on STEM student retention and associated demographic variables followed by a section on implications for the field. Finally, I will conclude with a summary of the information covered throughout this chapter and introduce Chapter three.

Background of STEM in American Higher Education

In 1862 the United States congress passed a revolutionary piece of legislation called The Morrill Land-Grant Act (Billings, 2012). By the mid-1800's, the US had an established system of classical colleges, like Harvard and Princeton that focused on classical languages and liberal arts education that harkened back to the ideological underpinnings of Oxford and Cambridge (Billings, 2012). Yet the needs of the nation and government were changing, and President Lincoln sought to boost the development of military, agricultural and mechanical studies

(Billings, 2012). Efforts to develop education and research in the technical studies continued to see support from additional legislation including (but not limited to) The Second Morrill Act of 1890 and the 1994 Land Grant Act in which large endowments were offered to states to establish technical and research universities across the country (Billings, 2012). The birth of the STEM system may be attributed to these types of national initiatives and legislation, as the Land Grant Acts were critical in establishing postsecondary education focusing on what we now call STEM. Later societal events only helped bolster the push for funding, research, and support of STEM education. For example, in the 1950's the Soviet Union launched a satellite called Sputnik which encouraged, amongst other things, a spirit of engineering and science competition in the American people (Gonzalez & Kuenzi, 2012).

The federal government spends approximately $3 billion annually on funding STEM initiatives, with the majority of funding directed towards the higher education system (Granovisky, 2018). Students are participating in STEM at increasing numbers relative to decades prior, with approximately 711,103 science and/or engineering bachelor's degrees awarded in 2019 (NCES, n.d.), significantly more than had been awarded about 40 years ago (Gonzalez & Kuenzi, 2012). However, the undergraduate rate of STEM growth has only managed to remain stable in comparison to the other fields of study (Gonzalez & Kuenzi, 2012), indicating that while the number of students has grown, the rate relative to overall undergraduates remains about the same and federal intervention may not be having the desired impact. Regardless, it is also important to note that overall growth in higher education participation is due, at least in part, to federally supported legislation. For example, in 1944 congress enacted the Servicemen's Readjustment Act, also known as the GI Bill, which granted financial subsidies and access to college education for millions of World War II veterans

(Kowalski, 2016). The veterans flocking to colleges and universities across the nation came with a range of needs and preparedness, as they had been out of the classroom for quite some time.

As we advance to the present day, the higher education system in the US continues to enroll students who come from a wide range of backgrounds and academic preparedness (Bastedo et al., 2016; Bettinger & Long, 2008; Blickenstaff, 2005; Casto & Williams, 2020; Crisp et al., 2017; Flynn, 2016; Greene et al., 2003; Hazari et al., 2013; Jones, 2015; King, 2016; Kreysa, 2007; Lee & Ferrare, 2019; National Center for Educational Statistics, 2012; 2018; Sonnert & Fox, 2012). Traditional measurements of the effectiveness of STEM education include retention, whether or not the student continued to return to the original institution, persistence, whether or not the student returned to *any* institution (Chen, et al., 2019), and graduation rates, which measure the number of students who complete their degree within six years. Academic preparedness impacts how well students perform in their college career and one measure of this has been retention. A recent review of data indicates that, in the US, only 56% of STEM students are persisting and when looking specifically at students of color, that number drops to 46% (Ortiz & Sriraman, 2015) these numbers point to a pipeline that clearly has too many leaks. With a national push to increase the number of students who graduate from STEM programs, the aforementioned persistence rates beg to be improved.

In the American system of higher education and development of STEM programs, there has been a theme of expanding access to the masses (Bastedo et al., 2016; Kowalski, 2016; Thelin, 2017). While this expansion may have had positive effects on society, not every college student is a product of a high-quality K-12 education (Bolick, 2017; Greene & Forster, 2003). Naturally, higher education has to adapt to the expanding diversity of students in regard to their level of academic preparedness for postsecondary education (Woods et al., 2018; Greene &

Forster, 2003). In terms of STEM education, there is a worry among many researchers, policymakers, and employers that the US is not adequately preparing and educating competent graduates to enter the workforce (Gonzalez & Kuenzi, 2012; Granovskiy, 2018). Without a competent and full labor force, stakeholders worry that the US will lack the resources and technology necessary to remain an economic leader and military power (Gonzalez & Kuenzi, 2012; Granovskiy, 2018). However, policymakers and key stakeholders must be clearly informed about the status of STEM education and measurements of success before making decisions on legislation and funding.

Keeping policymakers in mind, a report was published by the National Academies in which the status of the US postsecondary education system was criticized for areas of weakness in the STEM fields that would eventually lead to the deterioration of the US as a global leader in STEM (Committee on Prospering in the Global Economy of the 21st Century & Committee on Science, Engineering and Public Policy [National Academies], 2007; Granovskiy, 2018). Criticisms from the report include the low retention and graduation rates compared to liberal arts programs, projected widening of the gap between the "supply" of STEM graduates and workforce demand, and other countries such as China, Japan, and Taiwan increasing their STEM capabilities (National Academies, 2007). Since the publishing of the 2007 report, there has been a focus on how effective the US has been in developing and producing graduates of STEM programs (Granovskiy, 2018).

One of the important measures of how effective legislation, funding, and policy in higher education has been retention in STEM postsecondary education (NSCRC, 2015). Measuring the rates of retention is important because it helps educators and policymakers understand how effective the higher education system is (NSCRC, 2015). Logic indicates that higher rates of retention would be associated with effective higher education systems, funding, and policy. Continued enrollment in STEM postsecondary education assumes that students would be making progress towards attainment of the degree rather than dropping out (NSCRC, 2015). While efforts to retain students may have institutional and even federal costs associated with new initiatives and strategies, students are also responsible for a great deal of cost as they shoulder student debt, and a potentially stunted career path should they drop out.

Higher education has always been expensive. From the very early days college was often reserved for wealthy families; those who had less would have to make great sacrifices in order to send *maybe* one of their children off to college (Geiger, 2015). As access expanded for polytechnic and liberal arts institutions, so did the workforce, physical size of campuses, number of course offerings, programs, and, of course, costs to run the institution (Geiger, 2015). By 2012 the national student debt had amounted to over one trillion dollars, the largest source of US debt and, in fact, as of 2020 that number has risen to over 1.771 trillion dollars (Avery & Turner, 2012; FinAid, 2020). Ultimately, the STEM-pipeline has some unique challenges to address within a complex and imperfect system of higher education. In the next section I will discuss the primary challenges that institutions and students in the STEM-pipeline of postsecondary education face.

The STEM Pipeline & Higher Education Trends

With persistent challenges regarding STEM student retention, I am focusing my research specifically on how students in science, technology, engineering and mathematics (STEM) programs perform. The National Science Foundation (NSF) is a government agency that supports the advancement of various science research and related programs in the United States (US) (*National Science Foundation, n.d.*). The NSF defines "STEM" as programs that students participate in with a focus on science, technology, engineering or mathematics in both K-12 and postsecondary education (Granovskiy, 2018). The pipeline refers to the pathway that takes a student from their K-12 education to a degree in postsecondary, for the sake of this study the term STEM pipeline will refer to the process of students entering STEM programs at the university level.

This section aims to introduce the subject of the STEM-pipeline in the context of the American system of higher education. To outline some important national trends, according to the NCES Digest of Education Statistics, the 4-year and 6-year graduation rates for students who entered postsecondary education in 2013 was 45.3% and 63.4% respectively (Digest of Education Statistics, 2019-2020). As of 2020, the percent of people aged 25 and up and have at least a bachelor's degree, is 37.5%, almost an 8% increase from the previous decade (Digest of Education Statistics, 2019-2020). Yet this increase in enrollment also means there is potential for a larger population of underprepared students.

When investigating the national trends even further the graduation rate broken down by race, there are some disparities. For the 2013 national first-year cohort (all undergraduate students), those who identified as Asian had a 76.1% graduation rate, White students at 66.6%, Hispanic students at 57.8%, Pacific Islander students at 53.3%, Black students at 44.3% and, Native American students at 40.8% (Digest of Education Statistics, 2019-2020). It is important to note that those statistics are inclusive of all postsecondary institutions within the 6-year timeline to graduate and of students who graduated from their institution enrolled. These data are important to consider because it highlights the fact that there are disparities among who the system of higher education is working for and who appears to be lagging behind. While all groups of students and institutions can improve there should be a priority to identify and support those who are struggling the most, to create a more equitable system of education.

As outlined above, there are cohorts of students in college who the data indicate are struggling to graduate with a bachelor's degree within a 6-year timeline, but the expectations and rigor amongst academic fields can be quite different and need to be studied *for* those differences if we are to improve success rates and improve STEM student outcomes. There is a strong need for the growth of the STEM workforce, and we spend billions of federal dollars annually aimed at narrowing the demand and supply gap. Nationally, students in postsecondary STEM programs indicate a complicated picture of success and struggle (Granovskiy, 2018). The NCES (National Center for Education Statistics) reports that in 2019 just over 2 million undergraduate degrees were conferred, regardless of major, up from approximately 1.65 million in 2009. However, just 711,103 of those degrees were from STEM programs (NCES, 2021). While that STEM statistic is a sharp increase from a decade prior when only 415,178 STEM degrees were conferred (NCES, 2021), it still falls short of demand. These numbers indicate that perhaps some of our collective efforts are starting to improve the STEM pipeline but more needs to be done if students are to ultimately be retained by their institution and earn their degree.

While there are numerous potential strategies to be considered throughout each school, college, and classroom to improve the retention rates of students in STEM programs it may prove more effective to understand trends and themes among different demographic groups of students and their relative level of effectiveness. No program, strategy, support or intervention initiative will be universally potent for all students at all universities therefore, my research aims to build up the body of information related to the nuances of the STEM-pipeline. Particularly, STEM students being served by polytechnic institutions and how their experiences are similar or different from students at a non-polytechnic institution. In the next section, I will describe the theories and frameworks that guide and ground my research.

Theories & Conceptual Framework

To contextualize this research study and literature review I will draw from several theories and frameworks to ground my investigation. I have identified two theories as critical to understanding the challenges STEM students face: Social Reproduction Theory and the Leaky Pipeline Theory (Jaffee, 2020; Blickenstaff, 2005). Social Reproduction Theory (SRT) suggests that a person's ability to benefit from their human capital, or their skills, knowledge, experience, and personal connections, is impacted by their respective demographic characteristics (Jaffe, 2020). Therefore, a student of color with the same human capital as their White counterpart can expect the value of their capital to be different based on societal perceptions attached to their respective race and ethnicity. Of course, this example is rudimentary, and life does not exist in a vacuum. However, in context of the STEM pipeline, those two hypothetical students may expect their academic challenges to be mitigated differently with a higher potential for the student of color to see their capital be less impactful than their White counterpart in a system and society that tends to benefit White students more than others.

While SRT can help explain and understand the difference a student's capital may be "worth" based on their personal demographics (i.e., race/ethnicity, SES, gender, etc.) the Leaky Pipeline Theory (LPT) further provides an explanation for challenges students face. LPT assumes that in the higher education system, there are challenges and roadblocks that students are faced with and the internal evaluation of each experience and outcome informs each future decision; persist or drop-out (i.e., leak out of the pipeline) (Blickenstaff, 2005). Each time a student faces a challenge, that experience and outcome is internalized and used to inform future decisions.

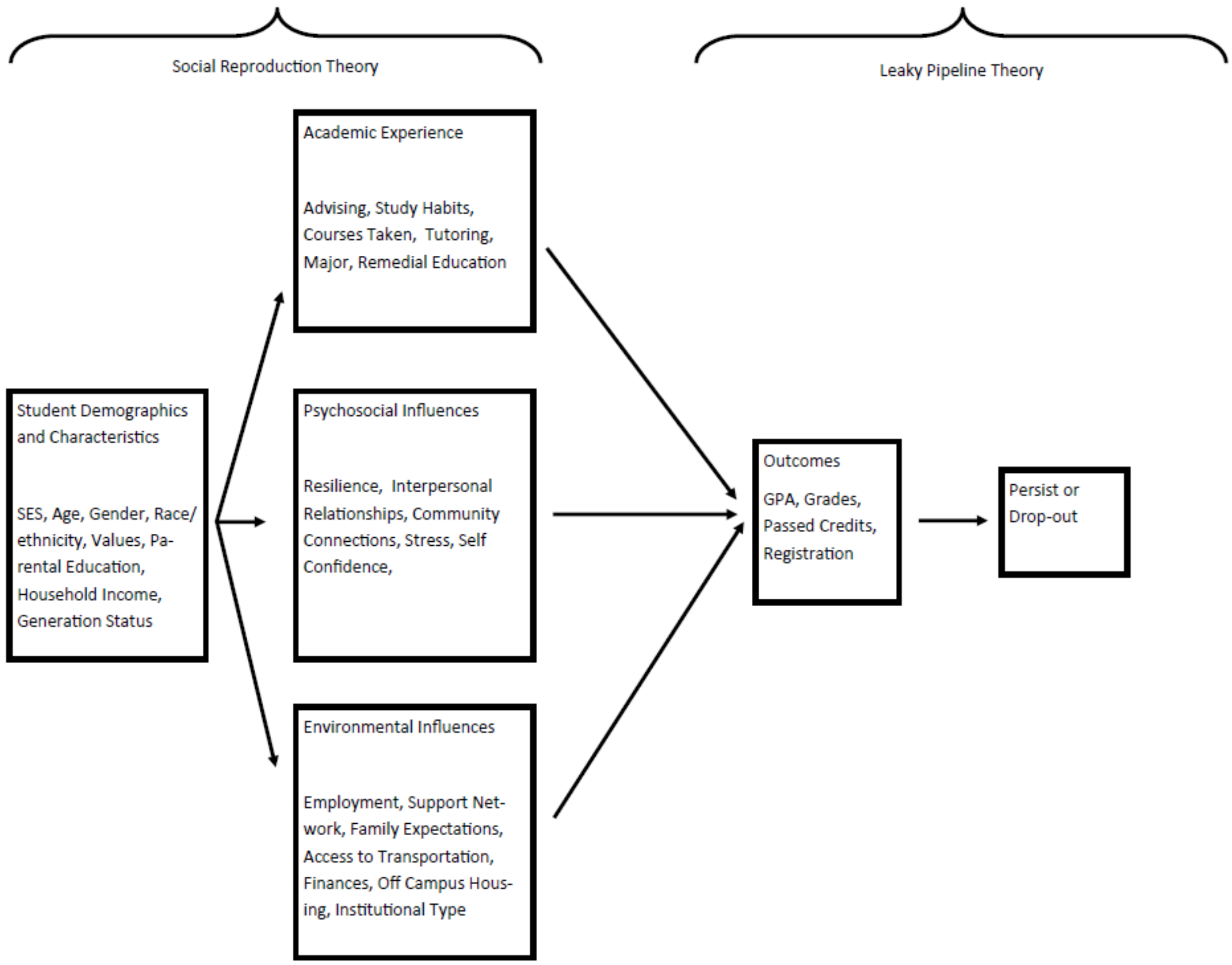
In addition to the leaky pipeline theory, the Blickenstaff (2005) study incorporated the foundational retention theory of Vincent Tinto. Tinto (1993) argued that student retention is a longitudinal process where the student has a series of interactions during their education that can impact their attitudes and perceptions of their experience. These attitudes and perceptions can impact their ability to succeed and in turn determine whether they continue at their college or university or not (Lee & Ferrare, 2019). Tinto's theory states that an individual's efforts and continuation towards a degree is most directly related to their connection to the academic and social systems of the university and without this connection, they are less likely to be retained (Tinto, 1993). Though Tinto's framework has helped to inform policy and practice, it assumes that students are of the *traditional* college student profile. Intervention strategies ought to be tailored to particular types of students in order to be most effective.

While Tinto's theory of retention is widely popular, an earlier theory may prove more influential and accurate. In 1980, John Bean created a conceptual framework to explain how various factors influence student success. In Beans (1980) framework, a student's demographic characteristics, academic experiences, environmental influences, and psychological makeup all interact to influence the likelihood of dropping out or leaving college (Bean, 1980). I used these broad themes to inform what variables to investigate. Bean's (1980) framework was also a response to help explain and understand non-traditional students' experiences, who did not fit the Tinto model for which students were assumed to be residential, 18-24 years old, full-time enrollment, do not work, etc., yet many students fall outside of this definition. Examples of students who may fall into the "nontraditional" category include (but are not limited to) those who commute to campus rather than residential students, or a student who is the first in their nuclear family to attend a 4-year institution, students who identify as minority status, students who work full or part-time, and so on (National Center for Education Statistics, n.d.-c).

As the majority of students in higher education, regardless of their program, are technically considered to fit into the *nontraditional* student demographic (i.e., non-residential, first-generation, etc.), Bean's (1980) framework can serve as a conduit to more accurately describe the potential impacts that the interaction between experiences, demographics and institutional variables may have. What these theories and framework provide is a foundation to explore and understand why students in the STEM-pipeline may not be successful and therefore that understanding can be more effectively utilized to inform research. Figure 1 below is a model I created of STEM student retention adapted from Beans (1980) model and in combination with SRT and LPT:

Figure 1

Proposed Model of STEM Retention



*Note***.** Each category includes example influences/characteristics, though the lists are not exhaustive, it helps define and contextualize each category.

In reference to Figure 1, variables for this research study will be organized by the four main categories: demographic variables, academic influences, psychosocial influences, and environmental influences. Key demographic characteristics include gender, race, socioeconomic status, and generational status. Academic influences are the experiences students have that relate to their courses and academics. The academic influence variables I will include in my research design include remedial education, the number of remedial credits and the subject matter (i.e., mathematics, English). It is important to investigate not just the subjects' students take at the remedial level but also how many credits or classes spent at that level as it could lead to disappointment or frustration for a student who is behind compared to their peers. Furthermore, looking into these academic variables will hopefully lead to a deeper understanding of how impactful they are long term on student retention in the STEM-pipeline at polytechnic institutions as compared to those at non-polytechnic institutions.

Psychosocial influences are associated with a student's connection to a community, stress, and resiliency, and so on. Students investing more time in their community is a positive thing and an institution that encourages or promotes opportunities for higher levels of positive psychosocial development will see stronger commitment and engagement from their students. The specific psychosocial influence variables I plan to include are on-campus employment, participation in campus tours, student's self-efficacy entering college, and attending instructor office hours. A student's psychosocial influences inform their decisions to continue or give up, whether they feel they are in the correct program or institution or not, how invested that student is in their STEM community, etc. These psychosocial experiences should have a meaningful impact on a student's likelihood to be retained.

Finally, environmental influences are the experiences or aspects in life that and can be a burden. The specific environmental influence variables I will include are off campus housing (i.e. commuter student status), off campus employment, level and types of tuition assistance. The physical environment that students are engaged with likely informs how that student will behave, participate, and invest their time and effort towards their academics.

In summary, the model in Figure 1 helped to guide this study in the variables studied and provide a context to explain potential analysis outcomes. I believe that this model could help higher education professionals understand retention factors unique to STEM students attending polytechnic campuses. In the following section I will discuss the current research conducted on students in the STEM pipeline of higher education.

Current STEM Research

The Underprepared Student

In this section I will review what researchers have found regarding the state, or profile, of students in the STEM-pipeline. By the early 2000s, nearly three out of every four first-year students began their university education in a remedial course (Parsad et al., 2000). With students entering college with varying levels of academic preparedness, institutions of higher education have been challenged to add resources and programs aimed at helping these aforementioned students to achieve success in college level courses, with the longer-term goal being that these students will reach graduation. Research on long term trends and predictive factors of academic success, retention and so on has been conducted using large national data sets like the Beginning Postsecondary Students (BPS) longitudinal study.

Another area of research has focused on understanding high school education and college readiness as potential predictive factors of later success in STEM postsecondary education. After analyzing data from the NCES *Digest of Education Statistics 2002*, Greene and Forster (2003) estimated the preparedness of high school graduates. Preparedness in this context was defined by Greene and Forster (2003), as having graduated from high school, demonstrated basic literacy and completed subjects in high school that colleges expect. The researchers found that only 32% of high school graduates met all three of those criteria and therefore were prepared for the academic rigors of college. When considering the national priority of improving the academic performance of students in the STEM-pipeline, 32% of high school graduates being prepared for *any* college major is an alarming statistic because STEM programs account for approximately 28% of all undergraduate enrollments (Chen, 2013). The research therefore indicates that most of these students are entering without the required level of academic skill and knowledge to be successful and therefore may struggle to be retained in their STEM degree.

Researchers found many important takeaways from the BPS 04/09 study that could help stakeholders better understand what factors influence and predict a student's academic ability and retention. Research of the BPS 04/09 data by Green and Sanderson (2018) found that educational experiences, institutional factors, and instructor availability were not predictive of students in STEM programs continuing in their degree; However, ability and demographic factors were predictive. Ability was defined by measures of grade point average, SAT/ACT scores and level of mathematics courses taken in high school whereas demographic details like level of socioeconomic status and parental education were also found to be predictive (Green & Sanderson, 2018). These important demographic variables, as I will discuss later, are key to my research study and will help inform the structure of regression models used for data analysis.

Many students take advanced high school classes known as Advanced Placement (AP), that are intended to provide students a college level of rigor for the subject material.

Surprisingly, however, students who entered postsecondary STEM education with AP mathematics courses were associated with lower rates of persistence (King, 2016) indicating that taking advanced courses in high school does not necessarily adequately prepare students for college level curriculum. Unfortunately, the link between high school education and college-level preparedness does not appear to be as straightforward as researchers hoped. If a high school education and AP level curriculum are not enough to prepare students for a STEM degree, something may be misaligned in the broader pipeline from high school to college. I want to acknowledge that there are academic factors that allegedly impact a student's preparedness. For example, learning a second language or studying art history may develop both creative and critical thinking, etc. that may therefore improve student aptitude in otherwise unrelated subjects however, this falls outside the scope of my research study.

Understanding academic factors that increase a student's likelihood to be successful in STEM programs at the post-secondary level is critical and, as discussed previously, can include factors outside of high school math and science classes. The risk for poor academic performance and dropping out may be higher for underprepared students enrolling at polytechnic institutions however, as Figure 1 suggests, a mix of academic, psychosocial, and environmental influences help explain this outcome. As an example, a student who did well in their high school math and science courses but performs poorly in those subjects at a polytechnic institution may internalize negative emotions and thoughts that weaken their self-efficacy, perhaps they work part time and therefore cannot attend tutoring until the student either fails out or gives up altogether. The combination of this hypothetical student's resources, academic experiences, human capital and academic outcomes help inform the likelihood of being retained or more inclined to drop-out of college. In the next section I will discuss how institutions have attempted to grapple with the surge in underprepared students with a focus on STEM student data where research from polytechnic institutions could not be readily found.

University Response to the Underprepared Student: Remedial Education

The research reviewed thus far has indicated that the majority of the population of students entering postsecondary education and enrolling in STEM programs are underprepared and many are struggling to persist. With the goal of improving the persistence rates of students in the STEM fields, universities across the country have attempted various practices to better support students in their academics and help them move along towards graduation. For students who are entering postsecondary education and are underprepared, universities have offered remedial, also known as "developmental," courses in mathematics, science and the humanities subject areas (Logue et al., 2017; Park et al., 2018). The remedial courses are intended to fill in the gaps of knowledge and improve academic skills to the level of preparedness that students need for college level coursework (Logue et al., 2017; Park et al., 2018). In the City University of New York (CUNY) system, Logue et al. (2018) found, similar to national trends, most students in mathematics courses below the college level struggled to pass, earned lower grades and were at a higher risk for leaving. One strategy that institutions of higher education have used is remedial education.

In the *remedial education* model, students who are underprepared for college-level coursework in certain subject areas, as noted either by placement exams or admissions criteria, take courses designed to prepare them for degree required curriculum (Kreysa, 2007). For example, a student may need to complete a pre-calculus course with subject matter that can range from algebra to trigonometry, before being eligible to take calculus or statistics. Although it may seem logical that a preparatory course would fill in the education gaps and promote later academic success, research indicates a different story. While some students benefit from the prerequisite based, *remedial education* model (Kreysa, 2007), often students struggle to pass their degree-required math courses and many drop out or transfer (Complete College America, n. d.; Gonzalez & Kuenzi, 2012). As the body of research grows showing that remedial courses do not solve the issue of under-preparedness, universities have a responsibility to explore new strategies. Remedial education may be impacting a student's academic experiences along with their psychosocial influences as mediating factors related to retention. While remedial education is academic in nature, I view it as adjacent to the program requirements as remedial courses do not typically count towards the program and therefore students in these classes may feel left out, lesser than, embarrassed, etc compared to their "on-track" and "prepared" peers. While there is nothing inherently negative or wrong with taking a remedial course, it has earned a negative stigma in the field of higher education.

Multiple studies have confirmed that students who complete remedial mathematics perform better in their mathematics than their peers who do not, at least in the short term (Bahr, 2013; Bettinger & Long, 2008; Buckles et al., 2019; Complete College America, n.d.; Conrad et al., 2018; Crisp et al., 2017; Eldin & Guy, 2019; Kashyap & Matthew, 2017; Logue et al., 2017; Park et al., 2018); however, what that actually means is complex. Much of the research conducted over the years has been spread across liberal arts, two and four-year institutions; however, in the context of STEM students, whose mathematics is an integral part of their curriculum, it is important to clearly understand how remedial education impacts performance. Ortiz and Sriraman (2015) found that, of the 2012 first-year cohort in the state of Texas, 7.4% were enrolled in a STEM major, yet only 56% of that cohort was retained compared to nearly 70% of non-STEM undergraduates. Instructors interviewed in the study articulated that part of the concern is simply with the nature of how remedial mathematics are set up (Ortiz & Sriraman, 2015). The outcomes of this study were partly attributed to students in remedial mathematics needing smaller class sizes, higher levels of engagement and instructional intervention (Ortiz & Sriraman, 2015).

One newer strategy, *corequisite developmental education* has been implemented at a handful of universities (Buckles et al., 2019). The corequisite developmental model (remedial and developmental labels can again but used interchangeably), in its simplest form, has students take the remedial course at the same time as the degree-required course in the same subject (Buckles et al., 2019). For example, an underprepared student may take a precalculus course at the same time as calculus. The goal in the aforementioned strategy remains the same as before, to prepare students and improve the likelihood of academic success and graduation. Corequisite models have yielded positive results early on, however, this model is still new and only implemented in a handful of colleges and universities (Complete College America, n.d.). Although the research in this area suggests some positive outcomes, namely that students timeline to graduation is not negatively impacted. Yet, it remains unclear how effective this model is for specific cohorts of student and if there is a meaningful difference in the course material.

In Dillard University, located in New Orleans, a corequisite model was implemented where students who otherwise would have placed below the college-level mathematics required by their engineering program, enrolled in both the remedial *and* college-level mathematics during their first semester (Buckles, et al., 2019). The results of this program at Dillard University were that 80% of the 140 students enrolled in the corequisite program earned a passing grade compared to 78% from the previous model (Buckles, et al., 2019). Regis College, though primarily a liberal arts institution, implemented a corequisite education model with their engineering students and also found preliminary though promising results (Kashyap & Matthews, 2017).

Researchers found that students in the corequisite education model were more likely to pass their courses and earn higher grades (Kashyap & Matthews, 2017). Unfortunately, the research conducted by Complete College America (n.d.) is not representative of 4-year polytechnic institutions nor STEM-dominant institutions. Jones (2015) however, alleges that 7 additional States plan to implement the corequisite education model though it is yet to be seen at what level. Furthermore, research is lacking when it comes to focusing on long term success as defined by timeline to graduation. The ideal scenario, I argue, is for students who are deemed to be underprepared to participate in support programs where graduation occurs in 4-6 years. However, what is problematic about the research thus far is that much of what we know comes from large college systems, and county colleges rather than polytechnic institutions or STEM dominant universities.

As Logue et al. (2017) have argued in their research on remedial education, these courses do not count towards graduation requirements, they cost tuition dollars and can add time to a student's collegiate career. In fact, Chicago, Illinois responded to these criticisms of remedial education by removing remedial education programs in postsecondary education and revamping its high-school preparation curriculum (Allensworth et al., 2009). However, academic success and levels of preparedness did not appear to improve, and failure and dropout rates remained unchanged. Policymakers could view Chicago's response as unhelpful and may not be prepared to implement similar measures in their city. Therefore, alternative strategies are being considered instead.

If not using the remedial or corequisite models of education, some colleges have attempted to change the nature of the curriculum itself and have implemented curricula in the STEM programs that are application-based, or more hands-on and practical in nature. According to a study by Plasman and Gottfried (2018) students who participated in applied STEM coursework persisted at a higher rate than their peers who did not. In fact, students who did not take applied STEM courses were 9% more likely to drop-out and students with learning disabilities were 12% more likely to drop out (Plasman & Gottfried, 2018). Rather than change the curriculum, another strategy has been to implement supplemental instruction, a form of guided study session for specific courses identified to be high-risk and key to retention and persistence (Eldin & Guy, 2019). Preliminary outcomes of the study conducted by Eldin and Guy (2019) indicated that students in remedial mathematics had higher pass rates when they participated in supplemental instruction sessions although it remains unclear if this strategy will improve persistence.

At the very least, it seems clear that the requirement model of remedial education is better than offering nothing at all or leaving it optional. In Florida, colleges with students admitted but underprepared for their required mathematics have attempted strategies such as making remedial courses optional. The research from Park et al. (2018) found that students who bypassed remedial education performed at lower levels of academic success and therefore at a statistically significant level of disadvantage. The Park et al. (2018) study recognized differences between student performance, either being slightly or severely underprepared based on standardized high school and entrance exam scores. Unsurprisingly researchers found that those who were only slightly underprepared were more academically successful in mathematics (Park et al., 2018). This research supports that there may be a benefit to targeted support for varied levels of under-preparedness for college-level mathematics. Other studies, such as Kreysas' (2007) conducted at highly selective, large, private institutions located on the west coast saw negligible difference in retention and graduation rates between students who participated in remedial mathematics and those who did not. Results of various customizations or add-ons to remedial courses have shown some improvements in student success (i.e., pass rates, GPA, retention, etc.). Yet, as the literature has so far shown, success appears to be limited depending on the size and type of institution, and perhaps even location. Research may need to study retention and other measures of academic success based on institutional type and/or location to glean a deeper understanding on the impact of academic initiatives to boost student preparedness.

Academic ability and how well a student fits in with the STEM community have been positively linked to increased rates of persistence (Le et al., 2014) and as such, some states and researchers have focused on investigating these factors further. In the state of Texas, researchers Means et al. (2018) analyzed the participation and preparedness of students who attended STEM specific high schools compared to students who did not. Means et al. (2018) found that STEM specific high school students were not only three times more likely to declare a STEM major in postsecondary education but that the students were also more likely to complete core STEM courses in their first two years. In regard to the participation and level of academic preparedness of students entering STEM programs, it appears that the Texas STEM-based high school system works well. The positive results of the Texas STEM-based high school system may be explained by students not only being prepared accurately at the high school level but having a stronger connection and commitment to the STEM field overall. Perhaps the curriculum and academic experiences students face in technical high schools is something that could be implemented across all high schools that are feeder schools to polytechnic institutions. To better understand who students in the STEM pipeline are, the next section will focus on various demographic characteristics.

Demographics: Gender, Race, SES, Generation Status

The previous subsection reviewed current literature pertaining to how prepared high school graduates are for a college education. However, this section will focus on sub-cohorts of students in the STEM-pipeline and how their experience may be different from their peers. Being able to identify support strategies or interventions that are predictive of higher retention rates by a student's demographics may help policymakers make more informed plans. Yet, researchers have studied numerous factors like gender, race, socioeconomic status, parental education level, learning disability, and so on to understand and predict likelihood of persisting in a STEM program. The focus of this study will aim to highlight relationships found regarding race/ethnic identity and gender identity, SES level and generational status with retention of a STEM programs.

Race/Ethnic Identity

Niu (2017) found white students (60%) are by far the dominant racial status among STEM students according to the data in the Educational Longitudinal Study:2002 (ELS:02). When looking at different racial or ethnic groups' performance in STEM programs, there have been conflicting results in recent years. For example, King (2016) found that race and ethnicity did not predict college success. However, other studies that also analyzed the BPS 04/09 data found that race and ethnicity *is* predictive of retention, persistence and success in STEM education with both Black and Latinx groups being at a greater risk for leaving the STEM field (Flynn, 2016; Riegle-Crumb et al., 2019). Furthermore, Riegle-Crumb et al. (2019) found that students who identify as Black or Latinx were 14-15% more likely to drop out when compared to their White counterparts. What this all means is that different racial/ethnic groups do perform differently and have different levels of persistence in STEM, leaving their White counterparts at an advantage. Despite the changing demographics within the US, we have not seen an equitable increase in participation in the STEM fields for minorities in colleges and universities. Participation in engineering and physical sciences within STEM remains stagnant as interest in mathematics has fallen particularly within students who identify as a minority race/ethnicity (National Science Foundation, 2015).

Gender Identity

Sonnert et al. (2012) studied what role gender played in a student's grade point average (GPA) for students in STEM programs but found that gender, defined as male or female, was not correlated. Further, both the number of female students and the male-to-female ratio in the program or college proved to be non-factors (Sonnert et al., 2012). Counter to prior research, Wade et al. (2017) further investigated student levels of preparedness entering a STEM program and their performance in their first level of mathematics (i.e., calculus) relative to their high school preparation and standardized test scores. Researchers found that students who identified as male tended to score better on the standardized tests, whereas students who identified as females consistently outperformed their male counterparts both in high school precalculus and calculus classes *as well as* at the college level (Wade et al., 2017). However, researchers did find that the type of institution classification was an important factor in predicting GPA for male and female students (Sonnert et al., 2012) with Research-I (via Carnegie classification) institutions being stable and non-Research-I seeing a wider disparity. However, researchers pointed out that women's programs established at non-Research-I institutions helped narrow the GPA gap significantly (Sonnert et al., 2012). While there are gender disparities throughout the STEM pipeline, a student's gender does not appear to be correlated to academic performance instead, institution type is correlated**.** Therefore, it again becomes important to investigate if there is a correlation between polytechnic institutions and student demographics like gender.

Following up on gender, King (2016) conducted a study analyzing data from Beginning Postsecondary Students Longitudinal Study (BPS 04/09) and found students' gender was not a predictive factor. This may indicate that gender equality exists at the postsecondary level for STEM programs. What Niu (2017) found in analyzing the data from the Educational Longitudinal Study:2002 (ELS:02) was that female students participate in STEM programs significantly less than males (37.8% to 62.1%). Despite initial performance and interest in math and science, females and minority status students were significantly less likely to identify as a STEM-type person compared to their white-male counterparts and less likely to continue in their STEM degree (Hazari et al., 2013). These results indicate that underrepresented student cohorts entering the STEM pipeline require socio-emotional support and esteem-building that their white-male counterparts already bring with them on day one. To clarify, participation in the STEM-pipeline is an important factor to understand as equitable representation and participation is likely to impact retention and persistence. For example, if a female student is ambivalent about their identity in the STEM fields and does not have representation in her peer group or among the faculty/staff, it could prove to be a motivating factor for that student to change majors or drop out.

What we learn about demographic trends among students in the STEM-pipeline will continue to remain a research priority as long as the demographics of the US population continue shift. We see that both a student's race/ethnicity and their gender appear to play an important role in how likely they are to be retained in a STEM program. These aforementioned demographic characteristics interact with a student's academic experiences and outcomes that ultimately impact whether or not they are retained at a STEM program at a polytechnic institution.

Socioeconomic Status

An important aspect of understanding who is entering STEM college programs is to look at the cohorts of socioeconomic status (SES) and their performance. While there is a lack of information specific to demographic characteristics and trends of students entering polytechnic institutions, national data regarding public 4-year institutions is widely available. For example, Niu (2017) opted to understand more about the relationship between socioeconomic status and enrolling in a STEM program in college. Researchers found that the level of family socioeconomic status (SES) was linked to the likelihood of students who are Black or Brown selecting a STEM program. In fact, researchers found that if a family who identified as part of a racial/ethnic minority, had an SES that was at the mean level, the student was more likely than their White counterparts to select a STEM degree and that likelihood increased as SES increased (Niu, 2017). These data point to access challenges and disparities in the STEM pipeline and may be due to factors related to resources available to Black and Brown students at various levels of SES.

Students at higher levels of SES often have access to better education, more support services and academic supplements, and time to spend on skill development. While higher levels of SES is associated with more resources and opportunities, it is not a guarantee that SES dictates student success or outcomes. However, building on the concept that certain populations and cohorts *tend* to lack access to supportive resources that may otherwise develop their skill sets and confidence, researchers have found a correlation between a student's self-efficacy beliefs and persistence in STEM programs (Hazari et al., 2013). Researchers, Hazari et al. (2013) studied students who entered science, engineering, and math programs at sampled 2 and 4-year colleges and found they had a range of differences when it came to self-perception and self-efficacy in the STEM subject areas. Therefore, it is possible that SES levels of students at polytechnic institutions may also be a factor related to student persistence.

Generation Status

In addition to minority status, another layer that can impact student academic performance and persistence is if the student is also a first-generation student. First-generation students are defined as students who are currently enrolled in postsecondary education with one or both parents not having a college degree (NCES, 2018). This is another factor where there is no inherent negativity or stigma attached but can increase the opportunity for a student to face additional challenges to navigating the college system. These students represent over 30% of total degree seekers in the U.S. and are among 70% of the total number of students who choose public institutions as their vehicle for degree attainment (NCES, 2012). Despite strong numbers of first-generation students entering the system of higher education, retention and completion rates do not match that of their peers.

First-generation students have a different path towards their degree than their continuing education peers (Padgett, et al., 2012). Continuing education peers are those who are in postsecondary education and have at least one parent with postsecondary experience (Redford, 2017). First-generation students often do not have the knowledge of campus resources to engage with or policies that they need to follow in order to be successful and therefore this potential burden provides them an additional challenge to overcome relative to their peers (Redford 2017). As the first-generation population grows and the demand for STEM laborers outpaces the supply, targeted intervention strategies remain a heightened priority for institutions. With over 16.5 million students estimated for Fall 2020 according to the U.S. Department of Education, National Center for Education Statistics (2020), it is critical to address challenges that some first-generation students face within the higher education. Regardless of generational status, entering college requires students to navigate a web of policies, expectations, and assumptions and this can at times prove to be a disadvantage for students and institutions alike as the students try to adjust to their new collegiate life.

Demographic Factors and Institution Type

As polytechnic institutions focus so heavily on in-depth mathematics and science curricula, a student who identifies as any of the aforementioned demographic characteristics outside of their White-male, upper/middle class continuing generation, peers, may be subject to increased opportunities to leak out of the polytechnic STEM-pipeline. The various areas in which someone's capital resources can be diminished, by no fault of their own, seeing as one does not get to choose what gender, race or level of household wealth they are born into, may lead to situations where academic, psychosocial and environmental influences have an even greater impact at a polytechnic institution relative to that of a non-polytechnic institution. Polytechnic institutions are likely better equipped than non-polytechnic institutions to aid in closing the gap between the supply and demand of STEM graduates due to their inherent focus on STEM programs, advanced technology and lab spaces, and overall specialization amongst staff however, as I have argued, a deeper understanding of who is being retained and why will promote more impactful support for students in the STEM-pipeline. In the final section of chapter two will conclude with a discussion of the gaps in the current body of research along with brief summary of the research covered throughout the literature review.

Conclusion

Summary of Research Themes & Challenges

In this section I highlight some areas of research that could benefit from additional research. Of the research reviewed in this study, most studies conducted relied on national datasets or data collected at the university level. While there is great value in the research already completed, I struggled to find research that focused on retention specifically polytechnic institutions outside of a few case studies; there is a clear gap in research that directly addresses the retention and degree completion of students at polytechnic institutions. It would be a great benefit to study how factors influence student retention at polytechnic institutions and if those factors level of influence is different at non-polytechnic institutions. Another important factor that has been researched over the years is gender and race/ethnicity gaps in student retention (Besler et al, 2018; Chen, 2013; Crisp et al, 2017; Eddy & Hogan, 2014; Flynn, 2016; Gonzalez & Kuenzi, 2012; Granovskiy, 2018; Jones, 2015; King, 2016; Riegle-Crumb et al, 2019). Although there has been conflicting data on gender gaps and student performance, the research confirms that the higher education system is not equitably supportive of students of color, particularly Black and Latinx students in STEM programs compared to their White counterparts (Besler et al, 2018; Chen, 2013; Crisp et al, 2017; Eddy & Hogan, 2014; Flynn, 2016; Gonzalez & Kuenzi, 2012; Granovskiy, 2018; Jones, 2015; King, 2016; Riegle-Crumb et al, 2019). Ultimately, higher education cannot maintain current its strategies and practices as the research shows the impact is not effective enough in improving retention for non-white students.

As indicated throughout this study, there are some inconsistencies in how predictive or impactful a student's demographic characteristics may ultimately be towards retention in STEM programs. The literature indicates that there are differences in academic performance among race/ethnicity groups (Besler et al, 2018; Chen, 2013; Crisp et al, 2017; Eddy & Hogan, 2014; Flynn, 2016; Gonzalez & Kuenzi, 2012; Granovskiy, 2018; Jones, 2015; King, 2016; Riegle-Crumb et al, 2019), whereas gender does not appear to be predictive of performance (Blickenstaff, 2005; Sonnert et al., 2012); however, it is unclear if these finding vary from institution type or if the outcomes would remain the same should institutional type be controlled for. Socioeconomic status also is a demographic characteristic that may require further investigation by future research in combination with a student's gender or racial identity. It is impossible to assume how any one variable may or may not have an association or predictive factor, therefore regression models will prove deeply important in this study.

The literature has indicated that intervention strategies that are academic in nature appear to have some moderate positive impact on STEM students' academic success. However, there is a lack of research and knowledge regarding the medium- or long-term impact of academic intervention strategies which is worrisome because we do not yet know if the effects are short lived or addressing the core issue(s). Furthermore, we do not have a wealth of research that directly focuses on STEM students at polytechnic institutions that could help clarify who is most at risk and perhaps even why they are at risk. It is important to understand that perhaps remedial courses help students with their foundational understanding, however we still need to investigate if it has an impact on student retention rates.

Finally, I believe that additional research needs to be done on addressing students who enter STEM programs that are underprepared as well as research on how effective remedial education programs are on degree attainment rates not just limiting the research to retention. A newer trend has been the implementation of a corequisite model where students who are deemed to be underprepared for the rigor of college education take both the remedial and program level courses in tandem however, only a limited number of colleges have attempted this practice and long-term outcomes remain to be studied. If corequisite programs can serve students better in their academic success and improve retention and lead to higher rates of degree attainment, then I see no reason not to move forward with implementation. However, research on corequisite education programs needs to happen first and it needs to be conducted at many different types of postsecondary institutions (i.e., STEM dominant, liberal arts, public, private, state systems, large-small, 4-year, etc.). With all this in mind, I will focus primarily on student retention and investigate degree attainment in an exploratory nature.

Conducting research across a wide and inclusive range of institutional types in relation to the true effectiveness of corequisite vs. prerequisite education strategies is critical for policy makers to be best informed on how to create, tailor and implement an appropriate model. There needs to be a push to apply institutional resources to more tailored support programs that address the unique needs of various populations in order to close the gap for students who are part of racial or ethnic minority groups, learning disabled, low socioeconomic status and other cohorts that are not part of the dominant population. Admittedly, a lofty goal to accomplish in the short term is to exhaustively research and study many subgroups of students in STEM postsecondary education; however, as the body of research grows the clearer the answer(s) will become for policymakers and key stakeholders. Now that an overview of the STEM-pipeline and prior research has been reviewed, the next chapter will explore the methodology of my research and how my study will be designed.

Chapter 3

Methodology

Introduction

In this chapter I outline and explain the research design and methodology that were used to explore and study my topic. As outlined in chapter one, this study investigated aspects of retention for students entering a STEM program at a four-year, polytechnic institution. As the literature has shown, the experiences of students from various backgrounds, socioeconomic status, levels of academic preparedness and type of institution attended can all have an impact on their relative success in the STEM pipeline. However, much of the research tends not to focus on the importance of institutional type (i.e., if the institution is a *polytechnic* institution). In this chapter I describe the research design and methodology used for my research. First, I briefly review the problem statement, purpose, and research questions for my research topic before moving on to a review of the data source and key variables used. Finally, I cover the research design and analysis of the data.

Problem Statement

Students entering postsecondary education in the STEM field are not attaining degrees at comparable rates to other academic fields despite tens of billions of dollars spent annually to improve the academic success for these students (Gonzalez & Kuenzi, 2012; Granovskiy & Library of Congress, 2018). An important part of a student's likelihood of completing their degree requirements and graduating from their program is being retained; students who stay in college are more likely to make progress than those who take time off or drop out. With the concern about the U.S.'s ability to remain a global leader for research and innovation, and growing demand for STEM graduates, more needs to be done to better understand this population of students. While a student must be responsible for their education, institutions that admit and enroll students share that responsibility and ought to promote opportunities for academic success linked to retention. Specifically, research needs to focus on STEM students attending polytechnic institutions, which primarily emphasize STEM.

Purpose

The purpose of this study was to add to the literature regarding the retention of STEM students, particularly those attending polytechnic institutions, which are known to focus primarily on STEM degree programs, and the similarities and differences between polytechnic and non-polytechnic institutions. Institutions have a responsibility to support the academic success of all students they admit, and it was my hope that this study, by investigating the characteristics of STEM students along with their academic, psychosocial, and environmental experiences, will better inform how higher education policymakers and key stakeholders design programs, resources, and support networks for students. The following Research Questions (RQ) were developed:

RQ1a: What factors predict STEM students' retention in polytechnic institutions (i.e., Academic Influences, Psychosocial Influences, and Environmental Influences)?

RQ1b: Do these factors differ for students at non-polytechnic institutions?

RQ2a: Does remedial education negatively impact STEM student's retention at polytechnic institutions?

RQ2b: Is there a difference in impact on retention based on the type of remedial course(s) taken (i.e., mathematics vs. English composition)?

The following research hypotheses were developed to examine Research Questions 1a and 1b:

Hypothesis 1 (H1): Environmental and psychosocial influences will be stronger predictors of student retention in their STEM program at polytechnic institutions when compared to academic influences.

Hypothesis 2 (H2): Environmental and psychosocial influences will be stronger predictors of student retention in their STEM program at polytechnic institutions than those at non-polytechnic institutions.

Research Questions 2a and 2b are exploratory in their nature, due to conflicting findings regarding the efficacy of remedial courses and did not have specific hypotheses attached to them. While it is important to investigate if there were meaningful differences and/or relationships between the related variables, the research is not particularly clear on who remedial education programs work best for especially now that universities have a range of methods to implement a remedial program (e.g., optional, pre-requisite, corequisite).

Data Source and Sample

I chose to use the 2009 High School Longitudinal Study (HSLS:09) dataset for numerous reasons; the relevant variables were present in this longitudinal dataset and the center that conducted the research has decades of experience conducting research in both the K-12 and postsecondary education realms. NCES researchers began conducting the HSLS:09 as the next iteration of their study of long-term academic and professional outcomes for students moving from high school through postsecondary education (HSLS:09, n.d.). The study tracked a nationally representative group of high school students, from their high school time through their college years in order to allow for a deep analysis of trends and student trajectories (HSLS:09, n.d.). A nationally representative sample is one that is demonstrative of the make-up of the overall population across the entire nation. Therefore, while not all students ultimately went to college, some dropped out or took time off, the sample collected matches the identity of the population regardless of geography or demographics and tracks their respective paths forward. For the purpose of my research, I focused on the data that followed high schoolers through their postsecondary education at public, 4-year polytechnic institutions and non-polytechnic institutions.

The rationale for using a secondary data set, HSLS:09, is that the data set is rich with information that is closely aligned with my research topic. The researchers collected demographic data on the students, measures for academic preparedness, whether they went to college, what type of college, what major, classes, etc. (HSLS:09, n.d.). The dataset is thorough and extensive in the information collected. Furthermore, it was impractical for me to collect this magnitude of data on my own.

For the data to be collected, a wide range of sources were engaged with, including the high school students, staff and instructors, and parents/guardians of the students. Data were collected from 9th grade students in 2009 via surveys, questionnaires, and a math assessment with a follow up conducted in 2012, when the students were in 11th grade. Researchers followed up with and tracked dropouts from the study. In 2013, when students were in their final year of high school, the researchers surveyed students regarding graduation and postsecondary plans. Data continued to be collected again in 2016, regarding students' experiences at the college level with transcript data collected the following academic year. The students in the longitudinal study were randomly selected from a nationally representative sample of 940 high schools, both public and private, with a final sample of 21,000 students (HSLS:09, n.d.). Restricted data will need to be accessed in order to group students by the type of institution they attended. By accessing the institutional title and IPEDS identification number, I coded whether students within the dataset attended either a polytechnic or a non-polytechnic institution. Students who attend county colleges or are identified as transfer students were removed from the sample because this study focused on first-time, full-time students at 4-year institutions. Only students who are enrolled full-time were used in this study with transfer students, part-time and non-matriculated students excluded because they would have additional variables, experiences and factors impacting their retention, persistence, and path towards degree attainment.

Demographic data were collected during the initial wave of the study in 2009. Variables like high school grade point average and self-efficacy measures were collected during the students' time in high school while college grade point average, remedial education courses and other postsecondary level data were collected through university files and questionnaires sent to the students during their time in postsecondary education. The dataset is a culmination of the research thus far released as of the second follow up wave in 2016 and the 2017-2018 postsecondary transcript collection wave, from NCES (National Center for Education Statistics [NCES], 2017). In the next section I detail the critical variables that were used in my research.

Research Variables

Outcome variable

Retention. The outcome variable for my study was whether the student was retained. This retention variable is dichotomous as either the student was or was not retained. The dataset included the enrollment status at the postsecondary level for students each year from 2010 to 2016 and this will be how entrance into postsecondary education and retention was verified. For this dichotomous variable, retention was indicated by "1" and those not retained indicated by "0".

Exploratory Analyses: Attainment. Although not directly related to my research questions, as an exploratory variable I also examined STEM degree attainment at polytechnic institutions. The sample may not be explicitly focused on degree attainment however, the HSLS:09 study does offer what could be described as preliminary insights into degree attainment as there will be a cohort of students who could have graduated by the 2017 collection wave. Therefore, I sought to investigate the number of students who were able to attain their STEM degree within the four-year timeframe as indicated by the transcript data. Future research would be necessary to further investigate degree attainment[2] after the follow up research wave is conducted in 2025.

Independent Variables

In this study, key demographic characteristics included gender, race, socioeconomic status, and generational status. In reference to the Figure 1 model of retention I have outlined the following variables organized by three main constructs in addition to the demographic variables: Academic influences, psychosocial influences and, environmental influences. A description from the codebook is included as well to further clarify the operationalization as it pertained to my research study.

Demographic Variables. In this study, key demographic characteristics included gender, race, socioeconomic status, and generational status. Of note, nominal categorical variables were recoded to include dummy variables so that proper analysis could be conducted. As limited by the variable definitions provided by the HSLS:09 study, gender was defined either as male or female but did not appear to offer additional identities or options. Socioeconomic status, a

[2] When reported in the follow up questionnaire and report in 2017, just 38 students had reportedly attained their degree from a polytechnic institution per the parameters established in my study. Therefore, no further investigation was conducted.

measure of a family's wealth and access to resources, is spread across quintiles with the first considered the lowest economic bracket and the fifth being the highest economic bracket. Race and ethnicity, often a meaningful identity for students, is broken down into eight categories typically used by NCES studies. While the initial survey data did not include information regarding the higher education status of participants siblings, generational status was identified by investigating parental/guardians' highest level of education with students whose parents had attended a 4-year institution, earned a bachelor's degree or higher, considered to be continuing generation rather than first-generation. Table 1 below summarizes the variables included in my research study.

Table 1

DEMOGRAPHIC Variable Table

Variable	Operationalization
GENDER *HSLS*: X1SEX	Nominal dichotomous variable indicating if a student identified as male or female.
RACE *HSLS*: *X1RACE*	Nominal categorical variable. Race/ethnicity the student identified with at the first wave of data collection in one of the following: *Amer. Indian/Alaska Native, non-Hispanic: Asian, non-Hispanic: Black/African American, non-Hispanic: Hispanic, no race specified: Hispanic, race specified; More than one race, non-Hispanic: Native Hawaiian/Pacific Islander, non-Hispanic: White, non-Hispanic.*

Variable	Operationalization
SES *HSLS*: X1SESQ5	Ordinal categorical variable identifying the family SES level in quintiles with 1 being the lowest and 5 being the highest, quintiles were established at every 20th percentile within the range of $15,000 - $235,000 (or more).
GENS HSLS: X1PAREDU	Dichotomous variable indicating if a student is first-generation status or not.

Note. Variable details pulled from the HSLS:09 codebook available in the public domain. From High School Longitudinal Study of 2009 (HSLS:2009-16, including PETS/SR), NCES (https://nces.ed.gov/datalab/onlinecodebook/session/codebook/4957e9fc-e224-4be1-9e90-0f14aea3f334)

Academic Influence Variables. Academic influences encompass experiences students have that relate to their curriculum and classwork. The specific academic influence variables I included in my research design were remedial education, including the subject matter of the class and the total number of courses taken at the remedial level. Regardless of the language surrounding the topic, be it remedial education or developmental education, the goal remains the same: support students' academic growth in key areas that may not have reached the level post-secondary education expected. For many students taking coursework at the remedial level helps to bolster their foundational knowledge, while for others it proves to be frustrating and perceived to be a barrier between them and their true degree credits. By including the total remedial English and mathematics coursework a student took, I hoped to learn about how these factors impacted retention, if at all. In the HSLS:09 dataset, remedial course subjects are boiled down to either mathematics or English, therefore those subjects were included as variables in this study. Table 2, below, outlines the academic influence variables included in this study.

Table 2

ACADEMICINF Variable Table

Variable	Operationalization
EREM, MREM *HSLS*: X5REMENTOT, X5REMMTTOT	Numerical variable that measures the number of remedial courses a student took during college in total, for English and for math. *HSLS, "Indicates the total number of known remedial courses that the student took for their undergraduate education as of June 2016."*

Note. Variable details pulled from the HSLS:09 codebook available in the public domain. From High School Longitudinal Study of 2009 (HSLS:2009-16, including PETS/SR), NCES (https://nces.ed.gov/datalab/onlinecodebook/session/codebook/4957e9fc-e224-4be1-9e90-0f14aea3f334)

Psychosocial Influence Variables. Psychosocial influences are related to a student's engagement with a community, levels of stress and resiliency, etc. The specific psychosocial influence variables that were included are participation in campus tours, student's self-efficacy entering college, and attending instructor office hours or seeking academic support like tutoring. This category of variables was the most difficult to define based on the dataset I used. Simply put, the researchers did not include data collection that explicitly addressed things like the number of student organizations or clubs participated in, or even the number of tutoring hours estimated to have attended and other factors that relate to a student's participation with peers, professors, the "community", etc. that would influence they psychosocial perspective. However, participating in a campus tour could presumably increase a student's connection with that community upon enrolling as they already have excitement, anxiety, curiosities and so on rooted in their firsthand tour. A student's belief in themselves to be capable and successful, self-efficacy, also lends itself to their overall psyche. Seeking out academic support also may indicate a student's perspective and comfort with themselves and the institution. Within the variables I was limited to, I selected the following as outlined in table 3:

Table 3

PSYCHOSOCIALINF Variable Table

Variable	Operationalization
TOUR *HSLS*: S2CLGTOUR	Dichotomous variable that indicates whether a student went on a campus tour or not. *HSLS, "Attended a program at, or taken a tour of a college campus."*
SELFEM, SELFES *HSLS*: X1MTHEFF X1SCIEFF	Ordinal numerical variables that measure the level of confidence a student has for math subjects and science subjects, respectively. *HSLS, "This variable is a scale of the sample member's math self-efficacy; higher X1MTHEFF values represent higher math self-efficacy..."* *HSLS, "This variable is a scale of the sample member's science self-efficacy; higher X1SCIEFF values represent higher science self-efficacy..."*

Variable	Operationalization
HELP *HSLS*: S4HELPCRSEVER	Dichotomous variable that indicates if a student sought out tutoring, professor office hours, or other academic help during their time in college. *HSLS, "Between the time you [received your high school diploma…] and […last attended reference institution…] had you ever sought help for a course such as by participating in a study group, going to office hours, or requesting tutoring?"*

Note. Variable details pulled from the HSLS:09 codebook available in the public domain. From High School Longitudinal Study of 2009 (HSLS:2009-16, including PETS/SR), NCES (https://nces.ed.gov/datalab/onlinecodebook/session/codebook/4957e9fc-e224-4be1-9e90-0f14aea3f334)

Environmental Influence Variables. Environmental influences refer to the factors that often are outside of a student's control (at least directly) and can potentially become a burden. The specific environmental influence variables that I included are campus housing (i.e., lived on campus or off campus), employment while in college, and types of tuition assistance. Again, as limited by the data collected by the researchers along with their respective definitions, I chose variables that represent or are likely to represent outside influences on a student's ability (i.e., capital). For example, if a student lives off campus and/or works off campus, they likely need to commute which means access to a personal car or public transportation and their off-campus employer may not be as flexible with work hours compared to on-campus supervisors. Those factors could lead to additional strain on a student's time, energy, and availability to be successful in their academics. It is possible that this category of variables may overcompensate or interfere with the findings related to the demographic variables and therefore to account for this I investigated the levels of variance inflation factor scores. In this study none of the variables VIF score was found to be particularly of concern. In table 4, the environmental influences variables are outlined:

Table 4

ENVIRONMENTALINF Variables Table

Variable	Operationalization
OCHOUSE *HSLS*: S4ONCAMPUS	A dichotomous categorical variable that identifies whether or not a student lived on-campus or not. *HSLS, "Where were you living in [February 2016/date last attended reference institution (through February 2016)] … 1=On campus or in college-owned housing, 2=Off campus"*
JOB *HSLS*: X3CLGANDWORK	A categorical variable that identifies whether or not a student had been working. *HSLS, "Sample member status for attending college and working."*
PELL *HSLS*: X5PFYPELLAMTCUM	Ordinal categorical variable that identifies the amount of Pell Grant assistance a student received, converted into a dichotomous variable of awarded Pell or not. *HSLS, "Total amount of federal Pell Grants received while enrolled at the primary institution during the first academic year attended postsecondary education after high school."*

Note. Variable details pulled from the HSLS:09 codebook available in the public domain. From High School Longitudinal Study of 2009 (HSLS:2009-16, including PETS/SR), NCES (https://nces.ed.gov/datalab/onlinecodebook/session/codebook/4957e9fc-e224-4be1-9e90-0f14aea3f334)

Control Variables. Finally, I decided to include the control variable as outlined in table 5 below. High school grade point (HS GPA) average can functionally be unequal depending on the school district student is enrolled in and can help level how well prepared a student was when entering college. The HS GPA variable in this dataset is spread along a 4.0 scale, with 0.0 as the lowest possible grade point average and 4.0 as the highest. This study also controlled for the level of selectivity as a university who is highly discerning in who they admit will understandably have a different cohort of students compared to a university whose mission is to serve the community and is more accepting in its admission requirements. Selectivity was broken into the following categories: Highly Selective, Moderately Selective, Inclusive, Selectivity Not Defined.

Table 5

Control Variables Table

Variable	Operationalization
SELECT *HSLS*: X4PS1SELECT	Ordinal categorical variable measured as highly selective, moderately selective or inclusive. *HSLS, "Indicates institutional selectivity of first postsecondary institution respondent attended after high school."*

Variable	Operationalization
HSGPA *HSLS*: X5GPAALL	Ordinal categorical variable measuring on a 4.0 scale, a student’s high school grade point average. *HSLS, “Grade point average weighted.”*

Note. Variable details pulled from the HSLS:09 codebook available in the public domain. From High School Longitudinal Study of 2009 (HSLS:2009-16, including PETS/SR), NCES (https://nces.ed.gov/datalab/onlinecodebook/session/codebook/4957e9fc-e224-4be1-9e90-0f14aea3f334)

Final Sample

The final sample for this study included 6,370 students from the original 21,000 plus students in the HSLS:09 dataset. The following details outline the demographic breakdown of the final sample. In this sample, approximately 45% identified as male and 55% as female. Regarding race and ethnicity, 0% identified as American Indian/Alaska Native, non-Hispanic, with another 0% identifying as Native Hawaiian/Pacific Islander, non-Hispanic. 1% of students identified as Hispanic, no race specified. 8% of the students in the final sample identified as More than one race, non-Hispanic. 8% of the final sample identified as Black/African American, non-Hispanic. 10% identified as Hispanic, race specified, 13% identified as Asian, non-Hispanic and 60% identified as White, non-Hispanic.

Regarding family socioeconomic status (SES), students were labeled among one of five categories with the first quintile being the *lowest* SES level and the fifth quintile being rated as the *highest* level of SES. The 1st quintile included 6%, the 2nd quintile included 9%, the 3rd quintile included 16%, the 4th quintile included 22% and the 5th quintile included 48% of the final sample. Regarding whether a student was the first-generation in their nuclear family to attend a 4-year college or not, 33% were first-generation and 67% were continuing-generation status. Table 5, below, details the demographic statistics:

Table 6

DEMOGRAPHIC STATISTICS

Variable		N	Valid Percent
Gender	Male	2900	46%
	Female	3470	54%
Race	American Indian/Alaska Native, non-Hispanic	20	0%
	Asian, non-Hispanic	320	13%
	Black/African American, non-Hispanic	490	8%
	Hispanic, no race specified	50	1%
	Hispanic, race specified	600	10%
	More than one race, non-Hispanic	470	8
	Native Hawaiian/Pacific Islander, non-Hispanic	20	0%
	White, non-Hispanic	3660	60%
SES	1st Quintile	350	6%
	2nd Quintile	550	9%
	3rd Quintile	920	16%
	4th Quintile	1290	22%
	5th Quintile	2830	48%
Generation Status	First-Gen	1770	33%
	Continuing-Gen	3550	67%

Source: The High School Longitudinal Study of 2009.

Regarding variables that fall under the Academic Influences category, there were 5,310 cases where students took remedial coursework at their college or university. While the data indicate that for the average was 0.4 (*sd*=1), the range of remedial English courses was 0 to 3 and for Mathematics was 0 to 8 courses. On average students took 0.1 remedial English courses (*sd*=0.3) and took an average of 0.3 mathematics remedial courses (*sd*=0.7).

From the Psychosocial Influences category, the majority of students had participated in a campus tour before attending college with 64% (N=3890) reporting they took a tour and 36%

(N=2190) reporting that they did not. Once at their respective college, 73% (N=4360) of students reported that they had sought out academic help and 27% (N=2190) did not. In reference to a student who reported self-efficacy pertaining to science, the range of scores was from -2.9 to 1.8, with an average of 0.25 (*sd*=0). The statistics for self-efficacy pertaining to mathematics were similar, with scores ranging from -2.9 to 1.6, an average of 0.28 (*sd*=1.0).

In the final sample, most students did not live in university sponsored, on-campus housing. 33% (N=1980) reportedly lived on campus, while 67% (N=3980) lived off campus either at their family home, an off-campus apartment, etc. Regarding students' employment status, 55% (N=2610) reported they were exclusively enrolled in college with 44% (N=2090) of students balancing college and a job or apprenticeship. The amount of Pell grants that students acquired ranged from $0 to $23,190 with an average of $3,545 (*sd*=5744).

Polytechnic & Non-Polytechnic Institutions

To code which institutions were considered polytechnic, the HSLS:09 dataset was merged with a secondary IPEDS dataset that matched an institution unique 6-digit code to the institution's name. Each institution was reviewed first by name, as many had already self-identified that they are a religious, polytechnic, business, or other type of school. For example, California Polytechnic State University clearly identifies itself as such whereas others include the term "institute of technology" like Stevens Institute of Technology. Universities and colleges found to be otherwise ambiguous by virtue of their name were reviewed in further depth by inspecting the institution's mission statement, any previous names since opening, programs offered and enrollment size of programs, etc. This information came either directly from IPEDs or the institution's website. Institutions that were 4-year, public or private not-for profit and had clearly defined promotion of STEM programs, research, applied education, and language in their mission statements and history descriptions consistent with polytechnic goals were coded as "Polytechnic" and those that were not coded as "Non-Polytechnic". Once institutions were identified as polytechnic or non-polytechnic, frequencies could be garnered to understand how many students attended each type. Ultimately, there were 420 students enrolled in polytechnic institutions (7%), and 5950 students enrolled in non-polytechnic institutions (93%). Next, will discuss the research model for my study.

Research Model

As covered in chapter two, the theories and conceptual framework utilized in my research are Social Reproduction Theory (Jaffee, 2020), the Leaky Pipeline Theory (Blickenstaff, 2005) and Bean's (1980) retention model. When combined into my suggested model of STEM retention, Figure 1, we contextualized and better understood what can lead to students leaving their STEM degree programs. As my research questions and variables were directly related to this model of retention, my study therefore tested these questions. Previous studies have found that demographics like a student's race or ethnicity, gender and socioeconomic status, and generation status can play a role in their retention (Niu, 2017; Padget at al., 2012; Redford, 2017; Riegle-Crumb et al., 2019; Sonnert & Fox, 2012). Variables related to academic preparedness (Almarode et al., 2014; Bahr, 2013; Buckles et al., 2019; Crisp et al., 2017; Freeman et al, 2014; Greene et al., 2003), psychosocial influences (Besler et al., 2018; Gibson et al., 2020; Hazari et al., 2013; Li et al., 2009; Means et al., 2018) and environmental influences (Heil et al., 2014; Lee & Ferrare, 2019; Li et al., 2009; Niu, 2017; Padgett et al., 2012) can also impact student retention. Based on my retention model and the literature, these characteristics were also included in my study. Although other prior studies have included the variables I included in my study, I believe my research is one of the first (if not, the first) to examine them through the scope of a polytechnic setting at the national level. Next, I outline the anticipated regression tests and models for my study.

Analytical Approach

My analytical approach was to utilize logistic regression models because this method of analysis is capable of assessing multiple independent variables towards the same outcome variable (Allison, 1999). For RQ1, my outcome variable was retention and my independent variables as listed in the prior sections were written out as their respective category title, DEMOGRAPHICS, ADACEMICINF, PSYCHOSOCIALINF, ENVIRONMENTALINF for simplicity and brevity. Of further note, multicategorical variables were recoded with dummy variables to help assess against a comparison group. With these variables in mind, I developed the following logistic regression model for STEM students at polytechnic institutions and the second model for STEM students at non-polytechnic institutions:

- $\text{POLYRETENTION} = \alpha + \beta_1\text{DEMOGRAPHICS}_1 + \beta_2\text{ACADEMICINF}_2 + \beta_3\text{PSYCHOSOCIALINF}_3 + \beta_4\text{ENVIRONMENTALINF}_4 + \varepsilon$
- $\text{NONPOLYRETENTION} = \alpha + \beta_1\text{DEMOGRAPHICS}_1 + \beta_2\text{ACADEMICINF}_2 + \beta_3\text{PSYCHOSOCIALINF}_3 + \beta_4\text{ENVIRONMENTALINF}_4 + \varepsilon$

The reasoning behind running separate models for investigating retention at polytechnic or non-polytechnic institutions was an attempt for simplicity as there are many variables included in the model. By running two separate models the outputs can be easier to review and compare. Regarding the analysis of retention in relation to remedial coursework taken, the original thought behind not including other variables like demographic variables was because those are already included in the previous analysis models and therefore these regressions would be a sub-analysis of sorts. Once the test models were run using SPSS, I reviewed the standard errors and coefficient values before running hypothesis tests to determine the *p*-value scores. Doing so was to help to confirm or reject H1 while also checking if another variable instead was found to be a predictor of retention at either polytechnic or non-polytechnic institutions. To assess how to respond to H2 I described the output and compared the *p*-values using the standard cutoff score of 0.05 to determine statistical significance.

For RQ2, my outcome variable remained retention. However, the independent variables this time were the total number of remedial mathematics courses taken (MREM) and the number of remedial English courses taken (EREM). I had originally intended to include the total number of remedial courses taken overall, however, upon investigation that variable was found to be too highly correlated with the other remedial variables and therefore was excluded from my analysis. For my control variables in this regression model, I controlled for college GPA as students may have other courses that influence their GPA differently and I controlled for institutional selectivity because different levels of selectivity will likely impact the level of preparedness of a student and the level of academic rigor at that institution. Demographic variables were not included to gauge the impact remedial coursework may or may not have as a standalone test whereas in the prior regression models, I investigated the potential impact multiple variables may be having on retention. To see the impact the total number of remedial coursed taken had on student retention I developed the following regression model with an identical model for students at non-polytechnic institutions as well:

- $\text{POLYRETENTION} = \alpha+\beta_1\text{MREM}_1 + \beta_2\text{EREM}_2 + \text{CONTROLV} + \varepsilon$
- $\text{NONPOLYRETENTION} = \alpha+\beta_1\text{MREM}_1 + \beta_2\text{EREM}_2 + \text{CONTROLV} + \varepsilon$

I conducted t-test and Chi square analyses to understand if there are meaningful differences between institution type among the demographics of students. These types of tests help provide additional clarity on not only on whether the populations of each institution are notably different from each other but may also help provide further context if it is found that the factors predicting retention differ in each institution.

Assumptions Check

Due to the number of independent variables, there was a possibility that some of them may be correlated and therefore the results could suffer from multicollinearity (Allison, 1999). Multicollinearity tends to skew the data analysis and negatively impact the reliability of the coefficient scores (Allison, 1999). A high level of VIF – the standard being that a score below 10 reflects a lower impact of multicollinearity among variables (Allison, 1999; 2001; Farahani et al., 2010). Upon investigation the VIF scores were reviewed and proved to not to be confounding and well below 10. I also reviewed the area under the curve (AUC) to investigate if the models would accurately identify true positives and true negatives, the higher the score the better the model and in this case the scores hovered around 5. This was done to help confirm the quality of the regression models and whether the resulting outputs are worth consideration or not. In the next section I explain the descriptive data and steps taken to address missing data before explaining the analyzed data and regression models.

Research Design

Missing Data

As with most research studies that rely on self-reporting and survey collection, there is a risk for missing data to be in the dataset. Variables that included -9 “missing data” were left as such however, there were variables with additional “missing” types were recoded for unity and simplicity. For example, the self-efficacy variables did not pertain to everyone in the study, some students did not take that assessment if they had reported they would not be taking a mathematics or science course in their fall semester, therefore those “Valid Skips” were recoded as “missing”. In the original dataset, there were students included who attended 4-year private, for-profit institutions, 2-year colleges, and trade schools, all those students were excluded from the final sample as they do not pertain to this study.

Validity

Ensuring that my research study is assessing what I intended to assess is critical to the validity of the results and overall study. To promote the validity of my study, I focused the results and discussions section regarding generalizability to clearly differentiate how the outcomes of my data analysis can inform key stakeholders working with STEM students at polytechnic institutions compared when the outcomes impacted those at non-polytechnic institutions instead. This will help protect the external validity of my study. Furthermore, the variables selected for my research were not only carefully cleaned for missing and extraneous data points but, were also variables that matched as closely to the pure definition as possible for example, race/ethnicity variable pulled from traditional and established categorical labels to promote construct validity. Confounding and extraneous variables pose a threat to any research but were addressed by carefully cleaning the variable data and taking care to have the data handling and variable selection reviewed by additional researchers, such as my dissertation chair and committee members. All these methods and considerations were done to ensure that from the start of the data review and analysis, sound practices were being executed for valid research results.

Ethical Considerations

As with any research study, there are ethical considerations to be addressed in order to protect the individuals participating in the research and ensure that the data and results are accurate, unbiased and responsibly handled. The data used in this study came directly from the HSLS:09 longitudinal study which was conducted by the National Center for Education Statistics (About Us, n.d.), a federal organization that studies education in the United States. NCES has a long history of quality assessments and longitudinal studies as can be reviewed on their webpage. To maintain the privacy and anonymity of the individuals who participated in the HSLS09 study, I focused exclusively on the relevant data and variables pertaining to my research questions. Furthermore, this study maintained all privacy requirements established by NCES. All of this will be done to protect the participants in the original longitudinal study.

Conclusion

The goal of chapter three was to provide readers with a clear understanding of the research methods being used in this research study. I outlined why a quantitative approach is appropriate and where the dataset originated from before detailing what types of variables would be pulled from the dataset, HSLS:09. I then went on to detail areas of validity and ethical considerations to account for. While no study is perfect, promoting the validity of research design helps to secure more accurate and faithful results along with the appropriate context to understand those results. The proposed methods of research design intentionally address the research questions identified throughout this dissertation and aim to fill the gap in literature addressing student's retention in STEM programs at polytechnic institutions. The following section, Chapter four, will focus on the results and outcomes of the data analysis conducted.

Chapter 4

Results

Descriptive Analysis: Comparing Polytechnic & Non-Polytechnic Institutions

Crosstabs Analysis

Gender. While more detail is shared in the tables proceeding this section regarding the demographics of students attending polytechnic institutions and those at non-polytechnic institutions, this section serves to highlight key differences. There remains a gender disparity among those enrolled at polytechnic institutions as 59% (250 students) identified as male and 41% (170) identified as female. The split at non-polytechnic institutions was not as stark but nonetheless inversely skewed with 44.6% (2650 student) identifying as male and 55.4% (3300 students) identifying as female. A chi-square test was performed to evaluate the relationship between gender and institution type, the relationship between the variables was $\chi^2(1) = 32.91$, $p < .001$, and therefore found to be statistically significant. It appears that there is a meaningful difference regarding gender at each institution type with polytechnic institutions primarily serving male students and non-polytechnic institutions serving mostly female students.

Socioeconomic Status. On the other hand, the spread of socioeconomic status was nearly identical between students attending polytechnic and those at non-polytechnic institutions. 6% of students at non-polytechnic institutions, and 3.3% of students at polytechnic institutions fell into the first quintile (the lowest SES level); 9.4% of students at non-polytechnic institutions, and 8.2% of students at polytechnic institutions fell into the second quintile; 15.6% of students at non-polytechnic institutions, and 14.5% of students at polytechnic institutions fell into the third quintile; 21.4% of students at non-polytechnic institutions, and 25.5% of students at polytechnic institutions fell into the fourth quintile; 47.5% of students at non-polytechnic institutions, and

48.5% of students at polytechnic institutions fell into the fifth quintile (the highest SES) level. A chi-square test was performed to evaluate the relationship between gender and institution type, the relationship between the variables was $\chi^2(1) = 8.44$, *p* .077 and therefore found not to be statistically significant. This implies that the socioeconomic difference is negligible between types of institution although the SES spread can be seen in Table 7.

Table 7

SOCIOECONOMIC STATISTICS

		1st Quintile (lowest)	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile (highest)	Total
No, Inst Not Poly	Count	340	520	870	1190	2640	5550
	% within POLY	6%	9.4%	15.6%	21.4%	47.50%	100%
Yes, Inst Poly	Count	10	30	60	100	190	390
	% within POLY	3.30%	8.20%	14.50%	25.50%	48.50%	100%
Total	Count	350	550	920	1290	2830	5940

Source: The High School Longitudinal Study of 2009.

First-Generation. Regarding the breakdown between generation status and institution type, both non-polytechnic and polytechnic institutions primarily hosted continuing generation students, their undergraduates representing 66.4% and 71.8% of their student body respectively. Non-polytechnic institutions reported that 33.6% of their undergraduates were first-generation students while polytechnic institutions reported that 28.2% of their undergraduates were first generation students. A chi-square test was performed to evaluate the relationship between gender and institution type, the relationship between the variables was $\chi^2(1) = 4.34$, $p = .037$ and therefore found to be statistically significant.

Race. Race and ethnicity are often an important part of a student's overall identity and worldview. When reviewing the race identity crosstab between students at polytechnic and non-polytechnic institutions, the proportional spread is similar between institutions with White, non-Hispanic students making up the majority of the cohort at 250 and 3400 respectively. From there, the second largest cohort were those who identified as Asian, non-Hispanic, then Hispanic, race specified, More than one race specified, then Black/African American, non-Hispanic, and so on. Table 8 shows the breakdown of identities among each institution type. A chi-square test was performed to evaluate the relationship between race and institution type, the relationship between the variables was $\chi^2(1) = 14.59$, $p = .042$ and therefore found to be statistically significant. Of note, at polytechnic institutions, there were 3% more students identifying as Asian then at non-polytechnic institutions. At non-polytechnic institutions, 3% more students identified as Black/African American then at polytechnic institutions. Regarding students who identified as White, polytechnic institutions had 3% more students identifying as White than non-polytechnic institutions. While the spread of students race identity may be similar between institutions, the cohort of students identifying as White, Black/African American, or Asian had notable differences between institution type indicating that perhaps each institution type is either attracting or recruiting different demographics of students.

Table 8

RACE/ETHNICITY STATISTICS

		Amer. Indian/ Alaska Native*	Asian*	Black/ African American*	Hispanic, no race specified	Hispanic, race specified	More than one race	Native Hawaiian/ Pacific Islander*	White*	Total
No, Inst Not Poly	Count	20	750	470	50	570	440	20	3400	5730
	% within POLY	0	13	8	1	10	8	0	60	100
Yes, Inst Poly	Count	0	70	20	0	40	30	0	250	400
	% within POLY	0	16	5	0	9	7	0	63	400
Total	Count	20	820	490	50	610	470	20	3660	6130

Note: *Indicates non-Hispanic

Source: The High School Longitudinal Study of 2009.

Independent Sample t-Tests

Table 9 outlines the basic statistics for the variables included in the independent sample t-Tests conducted in relation to socioeconomic status (SES), a student's status as first-generation, English remedial courses taken, mathematics remedial courses taken, and a student's self-efficacy (SE) score for mathematics and science.

Table 9

INDEPENDENT SAMPLE t-TEST DESCRIPTIVE STATISTICS

	INSTITUTION TYPE	*N*	*M (sd)*	Cohen's d	*t*
SES	No, Inst Not Poly	5550	3.95 (1.24)	-0.10	-1.96***
	Yes, Inst Poly	390	4.08 (1.12)		-2.15***
First-Generation	No, Inst Not Poly	4960	0.66 (0.47)	-0.14	-2.08***
	Yes, Inst Poly	360	0.72 (0.45)		-2.17***
English Remedial Courses	No, Inst Not Poly	4950	0.052 (0.26)	0.26	1.28
	Yes, Inst Poly	360	0.034 (0.19)		1.64
Math Remedial Courses	No, Inst Not Poly	4950	0.27 (0.71)	0.70	1.23
	Yes, Inst Poly	360	0.22 (0.57)		1.47
SE Math	No, Inst Not Poly	5090	0.27 (0.92)	-0.21	-3.88***
	Yes, Inst Poly	370	0.46 (0.92)		-3.88***
SE Science	No, Inst Not Poly	4830	0.24 (.095)	-0.19	-3.50***
	Yes, Inst Poly	350	0.43 (0.95)		-3.47***

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

Source: The High School Longitudinal Study of 2009.

What these analysis outputs indicate is there is a significant difference between school type and income bracket (i.e., socioeconomic status), in that students at polytechnic institutions (mean=4.08) compared to their peers at non-polytechnic institutions (mean=3.95), with the p-value equal to 0.05. When referencing the effect size, socioeconomic status had a Cohen's d score of -0.10, indicating small effect size (Cohen, 1992). Regarding whether a student was a first-generation college student or not, we find that more students at polytechnic institutions were likely to classify as first-generation (mean=0.72) when compared to their peers at non-polytechnic institutions (mean=0.66). This too was found to be a statistically significant difference with the p-value of 0.037 smaller than our 0.05 cutoff. Referencing the effect size, total remedial courses had a Cohen's d score of -0.14 and should be considered to have a medium effect.

The analysis outputs indicate is there is no significant difference between school type and having taken English or mathematics remedial coursework in that student at polytechnic institutions (mean=0.052;0.034) compared to their peers at non-polytechnic institutions (mean=0.27;0.22), with the p-value above the 0.05 threshold. When referencing the effect sizes, remedial coursework had a Cohen's d score of 0.26 for English and, 0.70 for mathematics indicating small effect size (Cohen, 1992). When evaluating the results of students reported self-efficacy towards math or science, students at polytechnic institutions had reported higher self-efficacy in both subjects (mean=0.46, =0.43) compared to their peers at non-polytechnic institutions (mean=0.27, 0.24) with both of these findings to be considered statistically significant as each of their p-values was <0.001. Yet, when looking into the effect size as shown in the table above, both self-efficacy subjects had mean differences considered to have medium effect.

Summary of Differences between Polytechnic and Non-Polytechnic Institutions

Ultimately, the descriptive statistics for the final sample indicate that there is, among gender, a statistically significant difference between students at polytechnic and non-polytechnic institutions (p=<.001). The number of students who are classified as first-generation in their family to attend college was also a statistically significant difference between the type of institutions (p=.037), however the t-Test results show that the effect size (d=-0.14) indicates a small effect size. A student socioeconomic status did not meaningfully differ between institution type (p=.077) this was also supported by the t-Test results that show the effect size was negligible at best (d=-0.10). When investigating differences between the number of remedial courses taken at polytechnic and non-polytechnic institutions it was found that the difference was not statistically significant (p=0.301) nor was the effect size (d=0.05). Differences in self-efficacy regarding math and science proved also to be more alike than dissimilar. While these results indicate that there are similarities between the populations at polytechnic and non-polytechnic institutions in the final sample, a student's gender and race identity proved to be of particular difference.

Research Questions 1a & 1b

In Research Questions 1a and 1b, I asked: What factors predict STEM students' retention at polytechnic institutions (i.e., Academic Influences, Psychosocial Influences, and Environmental Influences)? Do these factors differ for students at non-polytechnic institutions?

Regression Model Summary

Below outlines the two separate logistic regression model equations developed for research question 1a and 1b with their respective results used for comparison:

- $\text{POLYRETENTION} = \alpha + \beta_1\text{DEMOGRAPHICS}_1 + \beta_2\text{ACADEMICINF}_2 + \beta_3\text{PSYCHOSOCIALINF}_3 + \beta_4\text{ENVIRONMENTALINF}_4 + \varepsilon$
- $\text{NONPOLYRETENTION} = \alpha + \beta_1\text{DEMOGRAPHICS}_1 + \beta_2\text{ACADEMICINF}_2 + \beta_3\text{PSYCHOSOCIALINF}_3 + \beta_4\text{ENVIRONMENTALINF}_4 + \varepsilon$

Table 10 outlines the results of the regression analysis where the dependent variable was whether a student was retained at a polytechnic institution (1=retained) or not (0=not retained). The table reports the results of the covariates included: Gender (1=female, 0=male), Socioeconomic status or SES (1=1st quintile, 2=2nd quintile, 3=3rd quintile, 4=4th quintile, 5=5th quintile), Generation Status (1=first-generation, 0=continuing generation), Total remedial courses taken, English remedial courses taken, Mathematics remedial courses taken, Campus tour (1=Took campus tour, 0=Did not take campus tour), Self-efficacy score for Mathematics, Self-efficacy score for Science, Sought help in first-year of college (1=Yes, sought tutoring/office hours, 0=No), Housing status (1=Lived in on campus housing, 0=Did not live in on campus housing) Job status during college (1=College & working, 2=College only, 3=Working only, 4=Neither college nor working), Pell was converted to a dichotomous variable (1=received aid, 0=did not receive aid), and Race (Amer. Indian/Alaska native, non-Hispanic, Asian, non-Hispanic, Black/African American, non-Hispanic, Hispanic, race specified, More than one race, non-Hispanic, Native Hawaiian/Pacific Islander, non-Hispanic, White, non-Hispanic). The control variables, Institutional selectivity (1=Highly selective, 2=Moderately selective, 3=Inclusive, 4=Selectivity not identified) and high school GPA are also included at the bottom of the table.

Table 10

RETENTION BINARY LOGISTIC REGRESSION ANALYSIS

	Variables	Polytechnic (N=170) B (se)	*p*	EXP(B)	Non-Polytechnic (N=2210) B (se)	*p*	EXP(B)
	Regression Constant	-8.494 (4.316)	0.049	0	-4.462 (0.669)	<.001	0.004
Demographics	Gender	0.314 (1.009)	0.756	1.368	0.003 (.177)	0.76	0.947
	SES	0.373 (0.687)	0.587	1.452	0.034 (0.1)	0.037*	1.242
	First Generation	-1.437 (1.583)	0.364	0.238	0.394 (0.250)	0.19	1.396
Academic Influences	English Remedial Courses	-19.514 (5904.204)	0.997	0	-0.184 (0.286)	0.37	0.739
	Math Remedial Courses	19.195 (5904.203)	0.997	216830786.6	0.02 (0.088)	0.41	0.847
Psychosocial Influences	Took a Campus Tour	0.09 (1.136)	0.937	1.095	-0.027 (0.178)	0.99	1.001
	Self-Efficacy – Math	-0.59 (0.566)	0.298	0.555	-0.042 (0.095)	0.48	0.934
	Self-Efficacy – Science	-0.719 (0.715)	0.315	0.487	0.092 (0.095)	0.27	1.112
	Sought Academic Help	2.475(1.015)	0.015**	11.897	0.921 (0.176)	<.001***	2.58
Environmental Influences	Lived On-Campus	1.011 (1.103)	0.36	2.748	-0.305 (0.180)	0.08	0.729
	Working Status in College	1.682 (0.856)	0.05*	5.377	0.342 (0.160)	0.02*	1.449
	Awarded Pell	-0.903 (1.29)	0.469	0.406	-0.256 (0.192)	<.001***	1
Demographics	Amer. Indian/Alaska Native [a]	14.93 (40192.97)	1	3.049E+06	18.784 (13392.496)	1	1.15E+08
	Asian [a]	0.156 (1.29)	0.731	1.169	1.493 (0.476)	0.004**	3.96E+00

	Variables	Polytechnic (N=170) B (se)	p	EXP(B)	Non-Polytechnic (N=2210) B (se)	p	EXP(B)
Control	Black/African American [a]	22.286 (10299.453)	0.998	4.773E+09	0.656 (0.306)	0.39	1.309
	Hispanic, race specified	1.072 (1.723)	0.621	2.922	0.708 (0.284)	0.07	1.715
	More than one specified [a]	-2.478 (1.817)	0.167	0.084	0.249 (0.285)	0.58	1.173
	Hispanic, no race specified				20.049 (20954.724)	0.999	509647791.8
	Native Hawaiian/Pacific Islander [a]				19.042 (10973.233)	0.999	186209619.5
	Institutional Selectivity	-0.934 (0.787)	0.231	0.378	-0.219 (0.097)	0.24	0.803
	High School GPA	2.672 (0.894)	0.003**	14.475	2.016 (0.130)	<.001***	7.511
		R	*p*		R	*P*	
	Model Chi Square	55.693	<.001		602.509	<.001***	
	Cox & Snell R Square	0.279			0.239		
	Nagelkerke R	0.622			0.463		

Note. * p < .05. ** p < .01. *** p < .001. *df* for each predictor in the equation = 1. [a] Indicates non-Hispanic.

Source: The High School Longitudinal Study of 2009.

The analyses regarding retention at polytechnic and non-polytechnic institutions indicate that students' gender identity did not have a statistically significant impact on retention. The socioeconomic status of a student however, proved to have a positive impact (0.34) on retention at non-polytechnic institutions (p=0.037) but the same was not true at polytechnic institutions (B=0.373, p=0.587). Furthermore, a student's status as first-generation, the type of remedial courses taken, reported self-efficacy in mathematics or science, living on campus or having taken a campus tour were all found to have no statistically significant impact on retention regardless of institution type.

Students who sought academic help in their first year of college, be it tutoring or meeting with an instructor during office hours, was found to have a positive correlation with retention at both polytechnic (B=2.475, p=0.015) and non-polytechnic institutions (B=0.921, p=<.001). Being focused on just their academics (i.e., not working while in college) had a positive and statistically significant correlation (B=1.682, p=0.05) with retention at polytechnic institutions; at non-polytechnic institutions it was found that students who focused solely on their degree also saw a statistically significant, positive impact on their retention (B=0.342, p=0.02). While being awarded Pell aid to a student did not meaningfully impact retention at polytechnic institutions, it was found to have a correlation at non-polytechnic institutions (B=-0.256, p=<.001).[3] Interestingly, the regression models found that most race/ethnicity cohorts had no statistically significant relationship with retention compared with their White student peers. However, students who identified as Asian, non-Hispanic were found to have a higher likelihood at being

[3] Note that Pell data was heavily skewed with an overwhelming majority of students being awarded $0.

retained than their peers who identified as White, and at a statistically significant (B=1.493, p=0.004) level yet this was only true at non-polytechnic institutions.

The analysis conducted overall points out that regardless of institution type, students who seek out academic support are more likely to be retained by their institutions. Students who focus on just school were also more likely to be retained at both institution types. However, at non-polytechnic institutions a student's socioeconomic status and identity as an Asian, non-Hispanic student were also found to positively impact their likelihood of being retained compared to their peers. Other variables included in the regression models ultimately were found not to have a meaningful impact on retention at polytechnic and non-polytechnic institutions which may indicate that these populations are more alike than this study had originally thought.

Regression Model Accuracy

At polytechnic institutions according to the model, the observed number of students who were not retained was 10 students, whereas 150 students were observed to have been retained. Of the 15 students who were observed to have not been retained at polytechnic institutions, the model predicted 10 were predicted by the model, yielding a 60% accuracy score. Conversely of those observed to have been retained at polytechnic institutions 150 students were predicted by the model yielding a 99.4% accuracy score. The overall classification accuracy for the model is 96.5%.

Table 11

MODEL ACCURACY A

	Predicted		
Observed	Not Retained	Retained	Percent Correct
Not Retained	10	10	53.3
Retained	0	150	99.4
Overall Percentage			96.5

Source: The High School Longitudinal Study of 2009.

Furthermore, at non-polytechnic institutions according to the model, the observed number of students who were not retained was 120 students, whereas 1920 students were observed to have been retained. Of the 120 students who were observed to have not been retained at non-polytechnic institutions, the model predicted 120 were predicted by the model, yielding a 47.5% accuracy score. Conversely of those observed to have been retained at non-polytechnic institutions 1920 students were predicted by the model yielding a 98.8% accuracy score. The overall classification accuracy for the model is 92.7%.

Table 12

MODEL ACCURACY B

	Predicted		
Observed	Not Retained	Retained	Percent Correct
Not Retained	120	140	46
Retained	30	1910	98.3
Overall Percentage			92.1

Source: The High School Longitudinal Study of 2009.

Research Questions 2a & 2b

In Research Questions 2a and 2b, I asked: Does remedial education negatively impact STEM students' retention at polytechnic institutions? Is there a difference in impact on retention based on the type of remedial course(s) taken (i.e., mathematics vs. English composition)?

Regression Model Summary

The following logistic regression models were created to investigate the potential impact remedial education may have on student retention at each institution type:

- $\text{POLYRETENTION} = \alpha + \beta_1 \text{MREM}_1 + \beta_2 \text{EREM}_2 + \text{CONTROLV} + \varepsilon$
- $\text{NONPOLYRETENTION} = \alpha + \beta_1 \text{MREM}_1 + \beta_2 \text{EREM}_2 + \text{CONTROLV} + \varepsilon$

In Table 13 the results of the logistic regression analysis where the dependent variable was whether or not a student was retained at a polytechnic institution (1=retained) or not (0=not retained). The table reports the include the covariates included English remedial courses taken, Mathematics remedial courses taken, and includes high school GPA, and institutional selectivity as control variables. Overall, the model was predictive for student retention at non-polytechnic institutions (p=<.001) but not at polytechnic institutions (p=<.186).

Table 13

REMEDIAL IMPACT ON RETENTION

Variables	Polytechnic (N=360)			Non-Polytechnic (N=5950)		
	B (se)	*p*	EXP(B)	B (se)	*p*	EXP(B)
English Remedial Courses	0.140 (1.046)	0.893	1.151	-0.069 (0.166)	0.678	0.933
Math Remedial Courses	0.540 (0.422)	0.201	1.716	0.067 (0.06)	0.262	1.069
Institutional Selectivity	-0.480 (0.284)	0.091	0.619	-0.388 (0.054)	<.001	0.679
High school GPA	2.308 (0.342)	<.001	10.053	1.853 (0.072)	<.001	6.378
Constant	-3.405 (1.054)	0.001	0.033	-2.32 (0.226)	<.001	0.098
	R	*p*		R	*p*	
Model Chi Square	97.1	<.001		1209.861	<.001	
Cox & Snell R Square	0.239			0.218		
Nagelkerke R	0.468			0.398		

Note. *df* for each predictor in the equation = 1.

Source: The High School Longitudinal Study of 2009.

The analysis indicates that at polytechnic institutions (N=360), when controlling or institutional selectivity and a student's high school GPA, neither English or mathematics remedial courses were found to have a statistically significant impact on retention with their respective p values being 0.893 and 0.201. The situation at non-polytechnic institutions (N=5950) proved to be similar. English and mathematics remedial courses ultimately lacked statistical significance with their respective p values being 0.678 and 0.262. While individual students at either institution type may have a positive or negative impact on their chances of being retained, when investigating these variables on a larger scale, this study did not find that to be the case. The next section will focus on an overall summary of the analysis conducted before moving to chapter 5.

Summary

The results of this study point to a few interesting differences between what impacts retention at students attending polytechnic institutions compared to those attending non-polytechnic institutions. While it will take more time, dedication, and research to continue learning the nuances and patterns across various cohorts at each type of institution, I believe this study helps to build on prior related research.

In this study, I hypothesized that variables categorized as environmental influences (i.e., housing, job status, if Pell aid was awarded) and psychosocial influences (i.e., having taken a campus tour, sought academic help in their first year, self-efficacy in science and mathematics), would be stronger predictors of retention for students at polytechnic institutions and that academic influence variables (i.e., remedial mathematics courses, remedial English courses taken) would not. Based on the analysis conducted and the resulting outputs, for students at polytechnic institutions, academic influence variables were not relevant to their retention, although neither were most other variables studied. Having sought academic support (a psychosocial influence variable) and focusing on just academics instead of work (an environmental influence variable) proved to have positive correlations with retention, therefore I can moderately conclude that my original hypothesis had some weight and accuracy.

Next, I will discuss the overall findings in relation to student retention at non-polytechnic institutions. The original hypothesis was that again, variables categorized as environmental influences (i.e., housing, job status, if Pell was awarded) and psychosocial influences (i.e., having taken a campus tour, sought academic help in their first year, self-efficacy in science and mathematics), would be stronger predictors of retention for students at polytechnic institutions and that academic influence variables (i.e., remedial mathematics courses, remedial English courses taken) would not. The results were, in fact, similar to those found with polytechnic institutions however, this time a student's socioeconomic status, as well as those identifying as Asian, non-Hispanic, both are demographic variable, showed significant correlation to student retention. Nonetheless, it appears that the hypothesis for retention at non-polytechnic institutions can also appreciate modest acceptance based on the findings of this study. In the next chapter, I will discuss limitations, contributions, and implications for future research.

Chapter 5

Discussion

Introduction

This chapter serves to further explore the results discussed in chapter four. I provide my interpretation of the results, discuss the limitations of the study, contributions to the field, suggest future research, implications for policy and practice, and finally a summary conclusion. This study's purpose was to explore the relationships between student retention at polytechnic institutions and how that might be different from students attending non-polytechnic institutions. Therefore, the following research questions were developed and framed the research study:

RQ1a: What factors predict STEM students' retention in polytechnic institutions (i.e., Academic Influences, Psychosocial Influences, and Environmental Influences)?

RQ1b: Do these factors differ for students at non-polytechnic institutions?

RQ2a: Does remedial education negatively impact STEM student's retention at polytechnic institutions?

RQ2b: Is there a difference in impact on retention based on the type of remedial course(s) taken (i.e., mathematics vs. English composition)?

Research Questions 1a & 1b

The research and studies outlined in chapter two of this study pointed to certain themes and indicators impacting student success in higher education and STEM programs. It was clear that demographic variables like gender, generation status, socioeconomic status, and race were necessary to include in this research study both because they may indicate a relationship with retention and because this study had a goal to understand if there were differences among the student body based on institution type. The theoretical framework that informed this study's regression models included key variables also identified throughout the literature review. With this in mind, my study developed the following research questions: What factors predict STEM students' retention in polytechnic institutions (i.e., Academic Influences, Psychosocial Influences, and Environmental Influences)? Do these factors differ for students at non-polytechnic institutions? In other words, do things like taking remedial courses, seeking academic support, self-efficacy in important subjects, working full or part time while in college, living on or off campus, have an impact on retention?

I had originally expected psychosocial and environmental influences to have statistically significant correlations to student retention at polytechnic institutions. Both seeking academic support in a student's first year, a psychosocial influence variable, and working status in college, an environmental variable, were proven to be positively linked to student retention. While seeking academic support in a student's first year was proven to be positively linked with student retention at *non-polytechnic* institutions as well. However, working status in college resulting correlation with retention was unique to polytechnic institutions. Non-polytechnic institutions held additional unique variables associated with retention: Race identity as Asian, non-Hispanic and socioeconomic status. Therefore, the theoretical framework was not accurate in its current proposed state and the findings in this study point to a need to make revisions. Next, I discuss the findings in relation to the research requestions pertaining to remedial education before dissecting the theoretical framework in this study.

Research Questions 2a & 2b

The next set of research questions focused on the relationship between remedial education and student retention. Specifically: Does remedial education negatively impact STEM student's retention at polytechnic institutions? Is there a difference in impact on retention based on the type of remedial course(s) taken (i.e., mathematics vs. English composition). The goal was to investigate if either the subject type or having taken any amount of remedial education proved to have an impact on student retention. What this study found was that ultimately, there was no statistically significant association between retention and remedial education at polytechnic or non-polytechnic institutions.

The literature review explored that prior research had some conflicting outcomes and while many studies found that remedial education had some negative impact on student outcomes, be it their own self-efficacy or measures of retention and attainment (Complete College America, n. d.; Gonzalez & Kuenzi, 2012; Logue et al., 2017; Kreysa, 2007; Ortiz and Sriraman, 2015; Park et al., 2018), other studies contradicted that (Bahr, 2013; Bettinger & Long, 2008; Buckles et al., 2019; Complete College America, n.d.; Conrad et al., 2018; Crisp et al., 2017; Eldin & Guy, 2019; Kashyap & Matthew, 2017). As remedial education falls into the academic influences bucket of variables as informed by the theoretical framework this study incorporated and prior research indicated at least some level of interaction, it was logical to expect to find a potential correlation. While this did not prove to be the case, it may indicate that the proposed model of STEM retention was not accurate and could need further review or adjustments. In the next section, the proposed model of STEM retention (i.e., Figure 1) is discussed further.

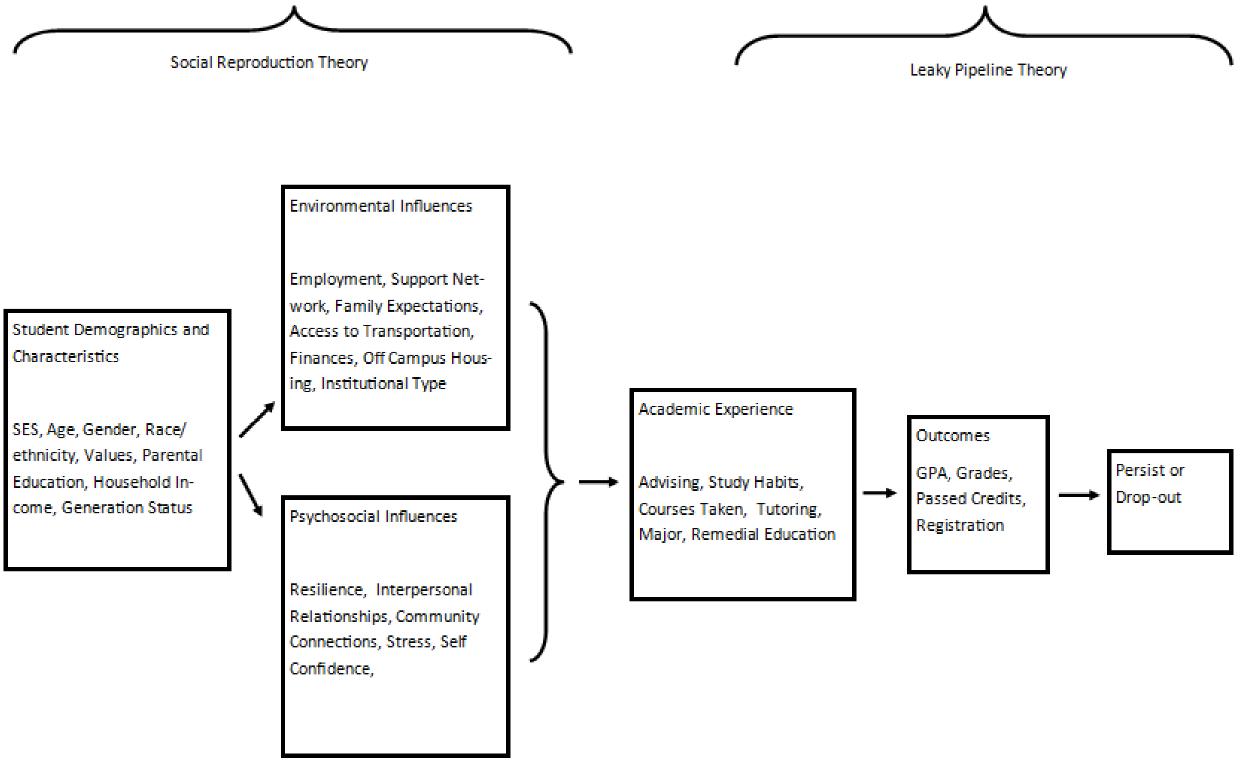
Proposed Model of STEM Retention

As a quick review, the model of STEM retention I proposed attempted to marry three theories: The leaky pipeline (Blickenstaff, 2005), social reproduction theory (Jaffe, 2020), John Beans model of nontraditional student retention (Bean, 1980). The leaky pipeline argues that with any system, there are going to be cracks or areas where students "leak" out therefore if we study the pipeline we can better identify and understand leaks to be addressed (Blickenstaff, 2005). Social reproduction theory argues that human and social capital is different for everyone due to the unchosen demographics a person holds and how society values or devalues those demographics (Jaffe, 2020). Finally, Beans model of retention suggested there are themes or buckets of variables that interact and inform student outcomes (i.e., grade point average, retention, attainment) (Bean, 1980). My model combines these theories to purport that the academic, psychosocial, and environmental influence buckets of variables also interact with a student's demographic characteristics and inform their capital in college and therefore can help inform us on student retention (a potential for students to leak out of the pipeline).

However, the results of this study highlight adjustments to consider. First, based on this study's findings the model proposed can shift the Social Reproduction Theory variable themes to focus on Environmental and Psychosocial Influences. Furthermore, academic influences may be more impacted by those variable themes rather than playing a primary role in student retention. In other words, academic experiences are an outcome of environmental and psychosocial variables. Future researchers may still find value in my proposed model or adjusted model and as more clarity is earned on the unique differences or ultimate similarities between students at polytechnic and non-polytechnic institutions the model can adjust to inform higher education professionals more accurately. In the next section I review additional findings related to the demographics of students at polytechnic and non-polytechnic institutions. In Figure 2 below, I created a revised model of student retention, based on the results of this study:

Figure 2

Revised Model of STEM Student Retention



Additional Demographic Findings

A few interesting points to note include some differences regarding the demographics between students attending polytechnic and non-polytechnic institutions, including gender and generation status. While the gender spread at non-polytechnic institutions favored those identifying as female, the opposite was true at polytechnic institution who favored students who identified as male. Regarding generation status, or whether a student was classified as first-generation or continuing generation, the split at non-polytechnic institutions favored continuing generation students but by a 2:1 ratio whereas at polytechnic institutions it appears that ratio shifted to nearly a 4:1 ratio. It is worthwhile to note as it indicates that either by attraction, recruitment, or coincidence the demographics between institution type does have some uniqueness to each cohort. As nuanced or dramatic as differences can be, the better we understand those differences the better we can accommodate our students and thus was the overall aim of this study.

Prior studies also indicated that a student's racial identity impacted their persistence and retention rates (Flynn, 2016; Riegle-Crumb et al., 2019) with students identifying as Black or Latinx being at a higher likelihood of dropping out than their White peers. Interestingly, this was not what proved to be the case when investigating the relationship of race on retention at polytechnic institutions. Instead, race identity at polytechnic institutions was found not to be associated with retention. At non-polytechnic institutions, students who identified as Asian, non-Hispanic were retained at higher rates than their White peers, a finding also identified in prior research studies (Digest of Education Statistics, 2019-2020). Regarding a student's gender, some interesting if not conflicting themes were found with some studies finding gender not to be correlated with retention (Sonnert et al., 2012) whereas others finding that gender did play a role in academic success with females earning higher marks in college mathematics courses (Wade et al., 2017). This study found that gender was ultimately not correlated with retention but did confirm there remains a disparity in gender representation in polytechnic institutions. This finding indicates there remains an issue within the STEM field and at polytechnic institutions to attract female students and improve representation. Further, as the race demographics at both polytechnic and non-polytechnic institutions showed a lack of representation, the findings that certain cohorts are being retained better than others point out that perhaps more can be done to improve representation and support.

Students who are the first generation in their family to attend a 4-year institution make up an estimated 30% of the undergraduate population (NCES, 2012). Researchers found that this group of students, often must spend more time learning about college policy, procedure, and expectations than their continuing generation peers who often get such information from their family members who already attended college (Padgett, et al., 2012; Redford 2017). However, this study found that first-generation students did not have their retention rates impacted at polytechnic nor non-polytechnic institutions. Therefore, while first-generation students may at times need to expend more effort to learn about higher education, it does not appear to have a negative impact on the ability to be retained.

Prior researchers also found that the level of socioeconomic status a student comes from was correlated with their intent to enroll in a STEM program at college, if they identified as Black or Brown (Niu, 2017). Because higher levels of socioeconomic status often increase the opportunity for more resources and better access to effective education, it was found that students who had high self-efficacy beliefs performed better in STEM programs (Hazari et al., 2013). While high levels socioeconomic status likely benefits students overall, this study found that at polytechnic institutions there was no meaningful association on retention. Therefore, it could be argued that socioeconomic status in relation to retention is not an area to be concerned with and that assumptions that students from lower levels of socioeconomic status are worse off than their peers, is not the case. In the next section, I will discuss possible limitations with my study.

Limitations

Inherent with using data from a prior research study, I am limited to the variables and data that were collected under the prior research design team. For example, while the data set is rich with useful information, institutions are not labeled categorically as “polytechnic” and therefore proxies were used to create a new variable that captures institutions with characteristics linked particularly to polytechnic institutions. While imperfect, proxy variables allow for a safe level of assumption to proceed with viable data and analysis. Similarly, because the dataset has predefined constructs and variables that are not explicitly identical to what my research focuses on, certain variables and constructs needed to be handled with additional care; whereas I may have created survey items to collect data about the number of clubs/organizations, campus events attended, tutoring hours completed and other measures related to campus involvement I had to rely on the variables that *were* present in the dataset. This limitation means that my research and results should take this construct adjustment into consideration particularly when attempting to make any generalizations.

Another limitation of this study is related to environmental conditions that the STEM and Higher Education system faces in 2022 being quite different than that of 2009-2016 when the data was collected; namely the Covid-19 pandemic has upended and changed the format of virtually all education formats for approximately two years. The impact(s) the pandemic has had on students entering the STEM pipeline may have significantly altered the impacts being assessed in this study, yet it is too soon to know. Thus, future research will assuredly need to address and study if there are marked differences in cohorts before and after the pandemic as related to STEM retention. Additionally, it remains to be seen and understood what the outcomes of the final HSLS:09 collection wave in 2025; the results of that additional data could impact the results found in my analysis or provide additional data and measures that would have been critical to include at the time my study was conducted. Nonetheless, with the data available at present, this research and outcomes should take all these limitations into consideration before making policy or changes in the education system.

One of the biggest limitations with this study relates to the final sample size; while the cohort of students enrolled in non-polytechnic institutions was nearly 6,000 the polytechnic cohort was considerably smaller, 400 students. While this was to be expected to some degree because there are significantly fewer polytechnic institutions, it does mean that the analyses and comparisons between institution types may be limited in their depth and applicability nationwide. Despite this limitation, this study remains important to begin how to better review the makeup of each student population and as a starting point for policymakers to consider how best to support students they represent.

Finally, another limitation to keep in mind is in reference to what truly constitutes a "polytechnic institution". Despite my best efforts to find a universally accepted definition or a description provided by a relevant government agency like NCES, it appears that one does not currently exist. Therefore, for my study I had to decide on a basic definition of what would count towards a 4-year polytechnic institution that primarily serves STEM students. Furthermore, while most institutions self-identify (i.e., public, private, liberal arts, business, nursing, religious, etc.) the type of institution they are, some do not. If an institution did not self-identify, I reviewed their mission statements, degrees and programs, and overall institutional profile to decide what type that institution counts as. While this work was largely expected and necessary to complete, future researchers should take time to think about what *should* constitute a polytechnic institution and share with folks how they came to that conclusion. Therefore, because my study had to decide how to differentiate polytechnic and non-polytechnic institutions, it is possible that other stakeholders and researchers may disagree. Implications for future research are discussed in the contributions section that follows.

Contributions

Implications for Future Research

If this study can serve as a foundation for developing or establishing a definition of what constitutes a polytechnic institution, future researchers should continue to adopt and refine the definition. Until a well-established and well publicized definition with clearly outlined criteria for what constitutes a "polytechnic" institution is available, my research can serve as a valid starting point. If this study is to serve as a starting point for clearly defining what constitutes a polytechnic institution I would recommend the following: A polytechnic institution is a 4-year public or private not-for-profit institution, with robust research programs (either earning R1 research status via Carnegie Classification standards or with aspirations to earn such status), serving undergraduate, graduate, and doctoral students whose programs are primarily under the STEM umbrella of subjects, whose curricula prioritizes applied education through well-developed co-operative education programs, integrated internship initiatives, extensive lab and workshop resources, and strong collaboration with related industry leaders. This definition aims to integrate important aspects that can be further defined and developed as the body of literature grows while also narrowing down the scope of viable institutions from over 4,000 but up from the amount considered by this study. What constitutes terms like robust, extensive, prioritizes, well-developed, etc. will depend on future studies adding to the understanding of uniqueness found at institutions to be considered polytechnic.

Furthermore, the results of the analyses in this study indicate that gender disparities remain at polytechnic institutions and thus among the STEM programs. While gender was not found to impact retention, the fact that disparity remains points to continued representation issues. Furthermore, if a student's race identity isn't impacting retention at polytechnic institutions it may be valuable to investigate if there are programs or initiatives at those institutions that negate any cohort from being ostracized or marginalized. Similarly, since socioeconomic status was found not to have a meaningful impact on a polytechnic student's retention, investigating why this is the case could lead to helpful insights on what institutions do to support their students effectively regarding their financial stability and resource access. Since it was found that students who sought out academic support in their first year were more likely to be retained than their peers, future researchers may want to study factors that promote and encourage students to seek that support.

The outcomes of this research study can have many applications and inform policy and practice however, the data was collected between 2009 and 2016. While that time frame is not particularly old, future research should take into consideration how, if at all, the pandemic has impacted student retention. The pandemic had a dramatic impact on all areas of our lives for about three years and many students lost critical time developing their academic and social skills during lockdowns. How that time in lockdown impacts a student's ability later in life to make connections, advocate for themselves, seek out resources like tutoring and professors' office hours may be at risk and future research should consider these components when studying student retention at polytechnic and non-polytechnic institutions.

Future research may also want to consider investigating how a polytechnic institution's geographic and regional location may impact retention of their students and the types of students they attract. Even the level of urbanicity may impact a student's experience and retention. These considerations were not taken into account in this research study but could prove to hold valuable insights on what may impact student retention and therefore what strategies could lend themselves to promoting retention. In the next section I will discuss how the results of this study can inform policy and practice in higher education.

Implications for Policy and Practice

Higher education professionals place value on students expanding their knowledge and utilizing college to reach their respective aspirations. While not necessarily unique to polytechnic institutions, policy makers may want to place value on the findings that students who sought academic support in their first year and students who focused on their academics instead of adding a job to their responsibilities, were more likely to be retained at their institutions. Therefore, support initiatives to promote and reward students who actively engage in academic support resources should be developed. Furthermore, ensuring students have the capacity in their schedule and their basic needs met should be at the forefront of policymakers and educators alike; perhaps in order to counter the loss of income and work experience, degrees can further incorporate co-operative education programs that encourage a mix of education, real world experience, and provide an hourly rate to the students.

Policymakers and key stakeholders should also continue to develop and promote initiatives that address the gender disparity seen in polytechnic institutions. Researchers consistently find that females are participating in STEM programs much less than their male peers and thus study confirmed further that at polytechnic institutions, the student body is again primarily male identifying. On the other hand, at non-polytechnic institutions, this study found the opposite to be true with the student body being majority female. Researchers may want to investigate if there are similar representation issues at non-polytechnic institutions among male identifying students though it is possible that representation disparity at non-polytechnic institutions may be mitigated by historical representation seen in the professional world whereas the same assumption likely cannot be made at polytechnic institutions; the trend for STEM programs and the STEM professional industry to be male dominated is consistent and uniform.

Since we know that representation matters in any industry or field, it will be important for students who identify as females to be better represented in STEM education. Furthermore, diversifying perspectives and viewpoints will continue to enrich the field with ideas and creative solutions to challenges our nation's STEM students and professionals aim to address. As future research builds on the knowledge base of what factors support or promote student retention, the discussion regarding policy will remain critical. In the next and final section of this chapter, I briefly provide a summary conclusion of this study.

Conclusion

My research study set out to explore student retention similarities and differences for students at polytechnic and non-polytechnic institutions. The results of my analysis indicate that seeking academic support in their first year and students who focused solely on their academics were associated positively with student retention at both polytechnic and non-polytechnic institutions. Furthermore, remedial education did not appear to have a relationship with student retention at polytechnic institutions regardless of subject type. While the student demographics at both institution types had some similarities, this study found that there are key differences in relation to students' race, gender, and socioeconomic status. With this knowledge, higher education policymakers and practitioners can refine their efforts to boost student retention and help ensure that more students make progress towards degree completion.

As the job market for students who graduated from a STEM program continues to swell, universities offering STEM programs will continue to need to develop strategies that promote student engagement in their academic community, encourage inclusion, access to academic support, etc. all with the intent of improving retention rates. Our students' needs change over time and consistently assessing what those needs are will be critical to the success of the institution and the student. I hope that the results of my research study help inform higher education practitioners and policymakers so that the pipeline leaks fewer and future researchers have a starting point for studying polytechnic institutions.

References

About Us. National Center for Education Statistics - About Us. (n.d.). Retrieved March 26, 2022, from https://nces.ed.gov/about/

Allensworth, E., Nomi, T., Montgomery, N., & Lee, V. E. (2009). College preparatory curriculum for all: Academic consequences of requiring algebra and english i for ninth graders in chicago. *Educational Evaluation and Policy Analysis*. *31*(4), 367–391. https://doi.org/10.3102/0162373709343471

Allison, P. D. (1999). *Multiple regression: A Primer (Pine Forge Press series in Research Methods and statistics)* (1st ed.). Pine Forge Press.

Allison, P. D. (2001). Missing data. SAGE Publications.

Almarode, J. T., Subotnik, R. F., Crowe, E., Tai, R. H., Lee, G. M., & Nowlin, F. (2014). Specialized high schools and talent search programs: Incubators for adolescents with high ability in stem disciplines. *Journal of Advanced Academics*, *25*(3), 307–331. https://doi.org/10.1177/1932202X14536566

Avery, C., & Turner, S. (2012). Student loans: Do college students borrow too much—or not enough? *The Journal of Economic Perspectives*, *26*(1), 165–192.

Bahr, P. R. (2013). The aftermath of remedial math: Investigating the low rate of certificate completion among remedial math students. *Research in Higher Education*, *54*(2), 171–200. https://doi.org/10.1007/s11162-012-9281-4

Bastedo, M. N., Altbach, P. G., & Gumport, P. J. (2016). American higher education in the twenty-first century: Social, political, and economic challenges. Fourth Edition. In *Johns Hopkins University Press*. Johns Hopkins University Press

Bean, J. P. (1980). Dropouts and turnover: The synthesis and test of a causal model of student attrition. *Research in Higher Education*, *12*(2), 155.

Belser, C. T., Shillingford, M. A., Daire, A. P., Prescod, D. J., & Dagley, M. A. (2018). Factors influencing undergraduate student retention in stem majors: Career development, math ability, and demographics. *The Professional Counselor*, 8(3), 262. https://doi.org/10.15241/ctb.8.3.262

Bettinger, E., & Long, B. (2008). Addressing the Needs of Underprepared Students in Higher Education: Does College Remediation Work?, 44(3), 736–771. https://doi.org/10.1353/jhr.2009.0033

Billings, R. (2012). The homestead act, pacific railroad act and morrill act. *Northern Kentucky Law Review*, *39*(4), 699–736.

Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education,* 17(4), 369-386. doi:10.1080/09540250500145072

Bolick, C. (2017). Jump-starting k-12 education reform. *Harvard Journal of Law & Public Policy, 40*(1), 17–24.

Buckles, E. L., Haydel, N. W., Thompson-Sanchez, J., & Page, Y. W. (2019). Implementing a corequisite algebra gateway course. *Peer Review*, *1–2*, 42. https://go.gale.com/ps/i.do?id=GALE%7CA601219321&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=15411389&p=AONE&sw=w&userGroupName=elizahs_ca&aty=ip

Burrus, J., Elliott, D., Brenneman, M., Markle, R., Carney, L., Moore, G., Betancourt, A., Jackson, T., Robbins, S., Kyllonen, P., & Roberts, R. D. (2013). Putting and keeping students on track: toward a comprehensive model of college persistence and goal attainment. Research Report. ETS RR-13-14. ETS Research Report Series.

Carey, T. (2015, July 15). *Repositioning the polytechnic university: Inside higher ed*. Higher Ed Gamma. Retrieved March 25, 2022, from https://www.insidehighered.com/blogs/higher-ed-gamma/repositioning-polytechnic-university

Casto, A. R., & Williams, J. A., III. (2020). Seeking proportionality in the north carolina stem pipeline. *High School Journal*, *103*(2), 77.

Chen, X. (2013). STEM attrition: College students' paths into and out of stem fields. Statistical analysis report. *NCES 2014-001*. National Center for Education Statistics. https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001rev

Chen, X. (2016). Remedial Coursetaking at U.S. Public 2- and 4-Year Institutions: Scope, experiences, and outcomes (NCES 2016-405). U.S. Department of Education. Washington, DC: National Center for Education Statistics

Chen, X., Elliott, B.G., Kinney, S.K., Cooney, D., Pretlow, J., Bryan, M., Wu, J., Ramirez, N.A., and Campbell, T. (2019). Persistence, Retention, and Attainment of 2011–12 First-Time Beginning Postsecondary Students as of Spring 2017 (First Look) (NCES 2019-401).U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved [date] from https://nces.ed.gov/pubsearch

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159. https://doi.org/10.1037/0033-2909.112.1.155

Coley, S. M. (2015). *The egalitarianism of honors at a polytechnic university*. Journal of the National Collegiate Honors Council, 2, 19.

College Board. (2021, October 27). *Trends in student aid 2019 highlights*. Trends in Student Aid Highlights. Retrieved November 10, 2021, from https://research.collegeboard.org/trends/student-aid/highlights.

Committee on Prospering in the Global Economy of the 21st Century (U.S.), & Committee on Science, E. and P. P. (2007). *Rising above the gathering storm: energizing and employing america for a brighter economic future*. [eBook]. National Academies Press. http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=nlebk&AN=191058&site=eds-live

Complete College America (n. d.). *Corequisite remediation: Spanning the completion divide.* Spanning the divide. https://completecollege.org/spanningthedivide/

Conrad, C., Commodore, F., Gasman, M., Lundberg, T., & Nguyen, T. (2018). Practices of remedial mathematics students who succeed in college: A case study of developmental math education at chief dull knife college, 42(1), 61–101. https://doi.org/10.1353/rhe.2018.0034

Crisp, G., Reyes, S., & Doran, E. (2017). Predicting Successful mathematics remediation among latina/o students. Journal of Hispanic Higher Education, 16(3), 232–255. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1142422&site=eds-live

Deslauriers, L., Schelew, E., & Wieman, C. (2011). Improved learning in a large-enrollment physics class. Science, 332(6031), 862. https://doi.org/10.1126/science.1201783

Digest of Education Statistics, 2019-2020. National Center for Education Statistics (NCES) Home Page, a part of the U.S. Department of Education. (n.d.). Retrieved November 9, 2021, from https://nces.ed.gov/programs/digest/current_tables.asp.

Eddy, S. L., & Hogan, K. A. (2014). Getting under the hood: How and for whom does increasing course structure work? CBE Life Sciences Education, 13(3), 453–468. https://doi.org/10.1187/cbe.14-03-0050

Edlin, M., & Guy, G. M. (2019). Mandatory and scheduled supplemental instruction in remedial algebra. *Journal of Developmental Education*, *43*(1), 2–10.

Farahani, H. A., Rahiminezhad, A., Same, L., & Immannezhad, K. (2010). A Comparison of Partial Least Squares (PLS) and Ordinary Least Squares (OLS) regressions in predicting of couples mental health based on their communicational patterns. *Procedia - Social and Behavioral Sciences*, *5*, 1459–1463. https://doi.org/10.1016/j.sbspro.2010.07.308FinAid. (2020, November 30). *Student loan debt clock.* Finaid. Retrieved November 30, 2020, from https://finaid.org/loans/studentloandebtclock/

Flynn, D. T. (2016). Stem field persistence: the impact of engagement on postsecondary stem persistence for underrepresented minority students. *Journal of Educational Issues*, *2*(1), 185–214.

Freeman, S., Haak, D., & Wenderoth, M. P. (2011). Increased course structure improves performance in introductory biology. CBE - Life Sciences Education, 10(2), 175–186. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ936344&site=eds-live

Freeman, S., Eddy, S., McDonough, M., Smith, M., Okoroafor, N., Jordt, H., & Wenderoth, M. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences of the United States of America, 111(23), 8410. https://doi.org/10.1073/pnas.1319030111

Fu, X., & Yue, H. (2017). Rethinking graduation and time to degree: a fresh perspective. Research in Higher Education, 58(2), 184–213. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1129797&site=eds-live

Geiger, R. (2015). *The history of American higher education: learning and culture from the founding to world war II.* Princeton University Press.

Gibson, A. D., Siopsis, M., & Beale, K. (2020). Improving persistence of stem majors at a liberal arts college: evaluation of the scots science scholars program. *Journal of STEM Education: Innovations & Research, 20*(2), 6–13.

Gonzalez, H. B., & Kuenzi, J. J. (2012). *Science, technology, engineering, and mathematics (STEM) education: a primer*. Congressional Research Service, Library of Congress.

Grace-Martin, K. (2016, October 14). What is an ROC curve? The Analysis Factor. https://www.theanalysisfactor.com/what-is-an-roc-curve/

Granovskiy, B., & Library of Congress, (CRS). (2018). Science, technology, engineering, and mathematics (stem) education: an overview. CRS Report R45223, Version 4. Updated. In *Congressional Research Service*. Congressional Research Service.

Green, A., & Sanderson, D. (2018). The roots of stem achievement: an analysis of persistence and attainment in stem majors. *American Economist*, *1*.

Greene, J. P., Forster, G., & Manhattan Inst., N. Y. N. C. for C. I. (2003). Public high school graduation and college readiness rates in the united states. Education Working Paper No. 3. In *Center for Civic Innovation*. Center for Civic Innovation.

Hazari, Z., Sadler, P. M., & Sonnert, G. (2013). The science identity of college students: exploring the intersection of gender, race, and ethnicity. *Journal of College Science Teaching*, *5*.

Heil, S., Reisel, L., & Attewell, P. (2014). College selectivity and degree completion. *American Educational Research Journal*, 51(5), 913-935. doi:10.3102/0002831214544298

HSLS:09. National Center for Education Statistics (NCES) Home Page, a part of the U.S. Department of Education. (n.d.). Retrieved March 26, 2022, from https://nces.ed.gov/surveys/hsls09/surveydesign.asp

Jaffe. A. (2020). *Social reproduction theory and the socialist horizon: Work, power and Political strategy*. Pluto Press.

Jones, S. (2015). The game changers: strategies to boost college completion and close attainment gaps. *Change*, *47*(2), 24–29. https://doi.org/10.1080/00091383.2015.1018085

Kashyap, U., & Mathew, S. (2017). Corequisite model: an effective strategy for remediation in freshmen level quantitative reasoning course. *Journal of STEM Education: Innovations & Research*, *18*(2), 23–29.

Kelderman, E. (2010). For advocate of women's choirs, fostering student engagement is a song. *The Chronicle of Higher Education*, *56*(41).

King, B. (2016). Does postsecondary persistence in stem vary by gender? *AERA Open*, *2*(4).

Kowalski, K. (2016). What shall we do with out boys? An impact of the GI bill on the us economy. *Ethics in Economic Life*, *19*(4), 167-180. doi:10.18778/1899-2226.19.4.12

Kreysa, P. G. (2007). The impact of remediation on persistence of under-prepared college students. *Journal of College Student Retention: Research, Theory & Practice*, *8*(2), 251–

270. http://baywood.metapress.com/link.asp?target=contribution&id=C90CPHWYG6B21N5E

Le, H., Robbins, S. B., & Westrick, P. (2014). Predicting student enrollment and persistence in college STEM fields using an expanded P-E fit framework: A large-scale multilevel study. *Journal of Applied Psychology*, *99*(5), 915–947. https://doi.org/10.1037/a0035998

Lee, Y.-G., & Ferrare, J. J. (2019). Finding one's place or losing the race? The consequences of stem departure for college dropout and degree completion. *The Review of Higher Education*, *43*(1), 221–261. https://doi.org/10.1353/rhe.2019.0095

Li, Q., Swaminathan, H., & Tang, J. (2009). Development of a classification system for engineering student characteristics affecting college enrollment and retention. Journal of Engineering Education, 98(4), 361–376. https://doi.org/10.1002/j.2168-9830.2009.tb01033.x

Liu, S. (2018). Entering the stem pipeline: exploring the impacts of a summer bridge program on students' readiness. *59*(5), 635–640. https://doi.org/10.1353/csd.2018.0060

Logue, A. W., Watanabe-Rose, M., & Douglas, D. (2017). Reforming remediation: college students mainstreamed into statistics are more likely to succeed. *Education Next*, *2*, 78.

Mandrekar, J. N. (2010). Receiver operating characteristic curve in diagnostic test assessment. Journal of Thoracic Oncology, 5(9), 1315–1316. https://doi.org/10.1097/JTO.0b013e3181ec173d

Marra, R. M., Rodgers, K. A., Shen, D., & Bogue, B. (2012). Leaving engineering: a multi-year single institution study. Journal of Engineering Education, 101(1), 6–27. https://doi.org/10.1002/j.2168-9830.2012.tb00039.x

Means, B., Wang, H., Wei, X., Iwatani, E., & Peters, V. (2018). Broadening participation in stem college majors: effects of attending a stem-focused high school. *AERA Open*, *4*(4).

Michel, J. O., Campbell, C. M., & Dilsizian, K. (2018). Is STEM too Hard? Using Biglan to Understand Academic Rigor and Teaching Practices across Disciplines. *Journal of the Professoriate*, *9*(2), 28–56.

Morales, E., Ambrose-Roman, S., & Perez-Maldonado, R. (2016). Transmitting success: comprehensive peer mentoring for at-risk students in developmental math. *Innovative Higher Education*, *41*(2), 121–135. https://doi.org/10.1007/s10755-015-9335-6

National Center for Education Statistics. (2012). *Improving the measurement of socioeconomic status for the national assessment of educational progress: A theoretical foundation.* Washington, D.C.: National Center for Education Statistics. Retrieved from: https://nces.ed.gov/nationsreportcard/pdf/researchcenter/Socioeconomic_Factors.pdf

National Center for Education Statistics. (2017). *2017 High School Longitudinal Study of 2009*. [Data set and code book]. NCES. https://nces.ed.gov/OnlineCodebook/Session/Codebook/870d2f50-a39e-42af-9870-d4fd8c544111

National Center for Education Statistics. (2018). *First-generation students: College access, persistence, and postbachelor's outcomes.* Retrieved from https://nces.ed.gov/pubs2018/2018421.pdf

National Center for Education Statistics. The Integrated Postsecondary Education Data System. (n.d.-a). https://nces.ed.gov/ipeds/Search/ViewTable?tableId=27427&returnUrl=%2Fipeds%2FSearch.

National Center for Education Statistics. (n.d.-b). Trend Generator. https://nces.ed.gov/ipeds/trendgenerator/.

National Center for Education Statistics. (n.d.-c). *Definitions and Data*. Nontraditional undergraduates / definitions and Data. Retrieved March 17, 2022, from https://nces.ed.gov/pubs/web/97578e.asp

National Center for Education Statistics. (n.d. -d). Fast facts. *National Center for Education Statistics*. Retrieved October, 2021, from https://nces.ed.gov/fastfacts/display.asp?id=372#College_attainment

National Science Board. (2012). Science and engineering indicators 2012 (NSB 12–01). Arlington, VA: Author.

National Science Foundation - Where Discoveries Begin. NSF. (n.d.). Retrieved November 10, 2021, from https://www.nsf.gov/about.

National Student Clearinghouse Research Center. (2015). *Persistence-retention. Snapshot™ report, spring 2015*. National Student Clearinghouse.

NSF. (2018, January). *NSF - National Science Foundation*. Science and Engineering Indicators 2018. Retrieved November 10, 2021, from https://nsf.gov/statistics/2018/nsb20181/assets/nsb20181.pdf.

Niu, L. (2017). Family socioeconomic status and choice of stem major in college: An analysis of a national sample. *College Student Journal, 51*(2), 298-312.

Ortiz, A. M., & Sriraman, V. (2015). Exploring faculty insights into why undergraduate college students leave stem fields of study- a three-part organizational self-study. *American Journal of Engineering Education*, *6*(1), 43–60.

Our polytechnic advantage. Our Polytechnic Advantage. (2021, September 28). Retrieved March 25, 2022, from https://www.uwstout.edu/about-us/mission-values/our-polytechnic-advantage

Park, T., Woods, C. S., Hu, S., Jones, T., & Tandberg, D. (2018). What happens to underprepared first-time-in-college students when developmental education is optional? The case of developmental math and intermediate algebra in the first semester. *Journal of Higher Education*, *89*(3), 318–340. https://doi.org/10.1080/00221546.2017.1390970

Parsad, B., Lewis, L., National Center for Education Statistics, E. W. D., & Westat, I. . R., MD. (2003). *Remedial Education at Degree-Granting Postsecondary Institutions in Fall 2000. Statistical Analysis Report.*

Passel, J. S., & Cohn, D. (2008). *U.S. Population Projections: 2005-2050* (Rep.). Pew Research Center.

Padgett, R. D., Johnson, M. P., & Pascarella, E. T. (2012). First-generation undergraduate students and the impacts of the first year of college: Additional evidence. *Journal of College Student Development*, 53(2), 243-266. doi:10.1353/csd.2012.0032

Payton, F. C., White, A., & Mullins, T. (2017). STEM Majors, Art Thinkers (STEM + Arts) -- Issues of Duality, Rigor and Inclusion. *Journal of STEM Education: Innovations & Research*, *18*(3), 39–47.

Plasman, J. S., & Gottfried, M. A. (2018). Applied stem coursework, high school dropout rates, and students with learning disabilities. *Educational Policy*, *32*(5), 664–696. http://dx.doi.org/10.1177/0895904816673738

Polytechnic campus. Polytechnic | ASU Campuses and locations. (n.d.). Retrieved March 25, 2022, from https://campus.asu.edu/polytechnic

President's Council of Advisors on Science and Technology. (2012). Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Washington, D.C.

Ramsay-Jordan, N. N., & Jett, C. C. (2020). A call to action: Lessons learned from a book club about supporting and mentoring underrepresented stem students. *Journal of Underrepresented & Minority Progress*, *2*, 271.

Redford, J. (2017). First-generation and continuing-generation college students: A comparison of high school and postsecondary experiences. Retrieved from https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2018009

Riegle-Crumb, C., King, B., & Irizarry, Y. (2019). Does stem stand out? Examining racial/ethnic gaps in persistence across postsecondary fields. *Educational Researcher, 48*(3), 133–144. http://dx.doi.org/10.3102/0013189X19831006

Saw, G., K. (2019). Remedial enrollment during the 1st year of college, institutional transfer, and degree attainment. *Journal of Higher Education, 90*(2): 298–321. https://doi:10.1080/00221546.2018.1493668

Soldner, M., Rowan-Kenyon, H., Kurotsuchi Inkelas, K., Garvey, J., & Robbins, C. (2012). Supporting students' intentions to persist in stem disciplines: the role of living-learning programs among other social-cognitive factors. *Journal of Higher Education*, *83*(3), 311–336. https://doi.org/10.1080/00221546.2012.11777246

Sonnert, G., & Fox, M. F. (2012). Women, men, and academic performance in science and engineering: The gender difference in undergraduate grade point averages. *Journal of Higher Education, 83*(1), 73–101. https://doi.org/10.1080/00221546.2012.11777235

Subotnik, R. F., Robert H. T., Almarode, J., & Crowe, E. (2013). What are the value-added contributions of selective secondary schools of mathematics, science, and technology? Preliminary analyses from a u.s. national research study. *Talent Development & Excellence*, *5*(1), 87–97.

Thelin, J. R. (2017). *American higher education: issues and institutions*. Routledge, Taylor & Francis Group.

Tinto, V. (1993). Leaving college: Rethinking the causes and cures of student attrition (2nd ed.). Chicago: University of Chicago.

Tolley, P. A., Blat, C., McDaniel, C., Blackmon, D., & Royster, D. (2012). Enhancing the mathematics skills of students enrolled in introductory engineering courses: eliminating the gap in incoming academic preparation. *Journal of STEM Education: Innovations and Research*, *13*(3), 74–86.

U.S. Bureau of Labor Statistics. (n.d.). *Employment in STEM occupations*. U.S. Bureau of Labor Statistics. Retrieved March 25, 2022, from https://www.bls.gov/emp/tables/stem-employment.htm

Wade, C. H., Sonnert, G., Wilkens, C. P., & Sadler, P. M. (2017). High school preparation for college calculus: is the story the same for males and females? *High School Journal*, *100*(4), 250–263. https://doi.org/10.1353/hsj.2017.0011

Wang, X. (2013a). Modeling entrance into stem fields of study among students beginning at community colleges and four-year institutions. Research in Higher Education, 54(6), 664–692. https://doi.org/10.1007/s11162-013-9291-x

Wang, X. (2013b). Why students choose stem majors: motivation, high school learning, and postsecondary context of support. American Educational Research Journal, 50(5), 1081–1121. Retrieved from http://search.ebscohost

Washington, G. (1790, January 8). *First annual address to congress.* The American Presidency Project. https://www.presidency.ucsb.edu/documents/first-annual-address-congress-0

White, D. W. (2013). Urban stem education: A unique summer program. *Technology & Engineering Teacher*, *72*(5), 8–13.

Woods, C. S., Park, T., Hu, S., & Betrand Jones, T. (2018). How high school coursework predicts introductory college-level course success. *Community College Review, 46*(2), 176–196. https://doi.org/10.1177/0091552118759419

Appendix A

Regression Model Builds

Logistic Regression Build for Retention at Polytechnic and Non-Polytechnic Institutions

The tables included in this appendix serve to explore the building up of the final regression model related to retention by institution type including academic, psychosocial, and environmental influence variables. Table 1 represents the first build and shows the statistical outputs for how the demographic variables related to retention.

Table 14

DEMOGRAPHIC IMPACT ON RETENTION

	Polytechnic (N=420)			Non-Polytechnic (N=5950)		
Variables	B (se)	*p*	EXP(B)	B (se)	*p*	EXP(B)
Gender	0.951 (.386)	.014	2.587	.542 (.087)	<.001	1.719
SES	.333 (.214)	.120	1.395	.22 (.047)	<.001	1.246
First Generation	.231 (.533)	.664	1.26	.638 (.128)	<.001	1.893
Amer. Indian/Alaska Native [a]	18.2 (40192.969)	1	80227074.54	.072 (.640)	.911	1.074
Asian [a]	.317 (.537)	.555	1.373	1.103 (.201)	<.001	3.014
Black/African American [a]	-.276 (.688)	.688	.758	-.338 (.142)	.018	.713
Hispanic, race specified				20.098 (11835.663)	.999	535106811.3
More than one specified [a]	1.319 (.798)	.098	3.741	.075 (.144)	.602	1.078
Hispanic, no race specified	-1.315 (.572)	.013	.268	-.104 (.153)	.497	.901
Native Hawaiian/Pacific Islander [a]				19.480 (8556.545)	0.998	28834456.3
Constant	-.796 (.808)	.325	.451	-.207 (.2)	.301	.813

Note. df for each predictor in the equation = 1. [a] Indicates non-Hispanic.

Source: The High School Longitudinal Study of 2009.

Next, I added psychosocial influence variables and controlled for high school grade point average. Table 2 displays the statistical output for this next model.

Table 15

DEMOGRAPHIC AND PSYCHOSOCIAL IMPACT ON RETENTION

	Polytechnic (N=420)			Non-Polytechnic (N=5950)		
Variables	B (se)	*p*	EXP(B)	B (se)	*p*	EXP(B)
Gender	.089 (.639)	.889	1.093	.041 (.149)	.781	1.042
SES	.044 (.402)	.913	1.045	.102 (.08)	.204	1.107
First Generation	-.032 (.914)	.972	.969	.359 (.211)	.089	1.432
Took a Campus Tour	.286 (.656)	0.663	1.331	.066 (.149)	0.656	1.069
Self-Efficacy – Math	-.463 (361)	.2	.63	-.015 (.082)	.855	.985
Self-Efficacy – Science	-.254 (.326)	.436	.776	.08 (.082)	.332	1.083
Sought Academic Help	1.140 (.621)	.066	3.128	.974 (.147)	<.001	2.648
Amer. Indian/Alaska Native [a]	15.948 (40192.969	1	8435503.289	1.071 (1.389)	.441	2.919
Asian [a]	-.400 (.944)	.672	.67	1.141 (.344)	<.001	3.130
Black/African American [a]	1.908 (1.493)	.201	6.741	.366 (.245)	.135	1.442
Hispanic, race specified				20.389 (18352.254)	.999	716170954.1
More than one specified [a]	.173 (1.035)	.867	1.189	.483 (.242)	.046	1.621
Hispanic, no race specified	-.991 (.952)	.298	.371	.112 (.242)	.664	1.118
Native Hawaiian/Pacific Islander [a]				19.022 (10448.417)	.999	182397221
High School GPA	2.457 (.479)	<.001	11.666	1.939 (.104)	<.001	6.95
Constant	-5.095 (1.782)	.004	.006	-4.723 (.413)	<.001	.009

Note. df for each predictor in the equation = 1. [a] Indicates non-Hispanic.

Source: The High School Longitudinal Study of 2009.

In the next model build I include the environmental influence variables to the regression equation and control for high school grade point average as well as institutional selectivity. Table 3 displays the statistical outputs for this model.

Table 16

DEMOGRAPHIC, PSYCHOSOCIAL, AND ENVIRONMENTAL IMPACT ON RETENTION

	Polytechnic (N=420)			Non-Polytechnic (N=5950)		
Variables	B (se)	*p*	EXP(B)	B (se)	*p*	EXP(B)
Gender	-.014 (.884)	.987	.986	.008 (.176)	.965	1.008
SES	.522 (.619)	.399	1.685	.036 (.1)	.721	1.036
First Generation	-1.396 (1.434)	.330	.248	.394 (.249)	.114	1.483
Took a Campus Tour	-.318 (1.079)	.768	.727	-.025 (.177)	.888	.975
Self-Efficacy – Math	-.583 (.511)	.254	.558	-.044 (.095)	.647	.957
Self-Efficacy – Science	-1.07 (.675)	.113	.343	.093 (.095)	.329	1.097
Sought Academic Help	2.213 (.931)	.017	9.143	.923 (.176)	<.001	2.516
Lived On-Campus	.98 (.934)	.294	2.666	-.308 (.179)	.086	.735
Working Status in College	1.351 (.796)	.089	3.862	.338 (.16)	.034	1.402
Awarded Pell	-.123 (1.062)	.908	.884	-.254 (.191)	.184	.776
Amer. Indian/Alaska Native [a]	15.46 (40192.97)	1	5180272.149	18.76 (13402.779)	.999	140395905.3
Asian [a]	-.251 (1.176)	.831	.778	1.494 (.474)	.002	4.456
Black/African American [a]	21.513 (10887.715)	.998	2202162669	.658 (.305	.031	1.93
Hispanic, race specified				20.052 (20949.866)	.999	510891188.6
More than one specified [a]	.287 (1.44)	.842	1.332	.696 (.283)	.014	2.006
Hispanic, no race specified	-2.514)	.133	.081	.234 (.283)	.409	1.263
Native Hawaiian/Pacific Islander [a]				19.048 (10973.03)	.999	187271665.9
Institutional Selectivity	-.686 (.704)	.33	.502	-.218 (.097)	.024	.804
High School GPA	2.49 (.72)	<.001	12.06	2.016 (.128)	<.001	7.509
Constant	-7.12 (3.174)	.055	.001	-4.473 (.665)	<.001	.011

Note. df for each predictor in the equation = 1. [a] Indicates non-Hispanic.

Source: The High School Longitudinal Study of 2009.

The final model build, covered in the main text of this document incorporated demographic, psychosocial, environmental, and academic variables and controlled for high school grade point average as well as institutional selectivity.